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VOLUME XII

MARCH TO DECEMBER,
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MARCH TO DECEMBER, 1907, INCLUSIVE.

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COMPRESSED AIR

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FOUNDATION PROBLEMS IN NEW YORK CITY

C. M. Ripley.

Preventing Collapse of Neighboring Buildings. Caissons Sunk to Bed-Rock by Pneumatic Process; Latest Method With Moran Air Lock.

The gigantic increase in the erection of skyscrapers in the "Lower Broadway" section of New York City during the past few years, has been made in the face of grave and increasing engineering difficulties. A study of the laying of the foundations for the Trust Company of America (see Fig. No. 1), now nearing com-

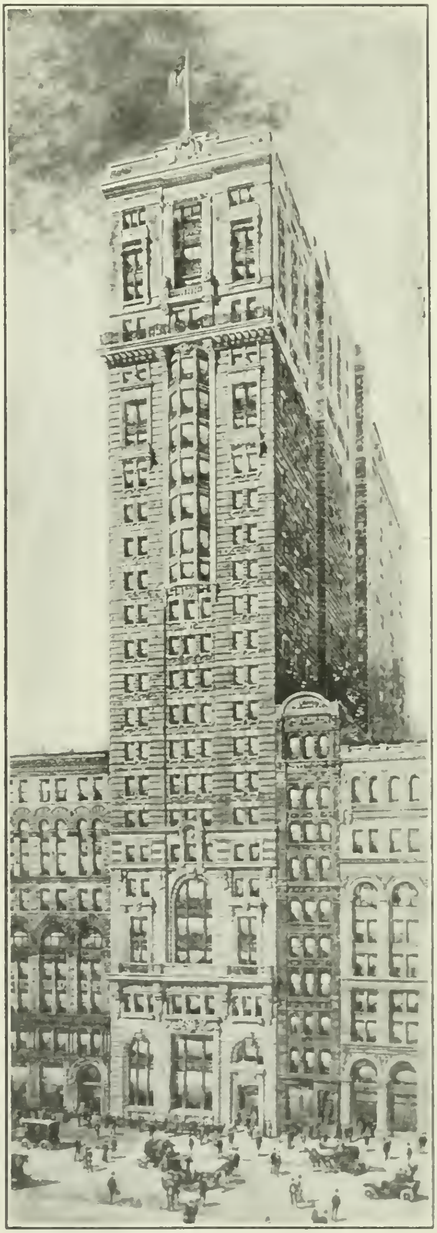

FIG. 1.

pletion in the financial section of Wall Street, will bring out forcefully: (1) What these problems are, and (2) how the talent of engineering contractors has been developed. Less than a dozen years ago the following conditions would have been considered *insurmountable obstacles* making impossible the construction of a twenty-five story building on this site.

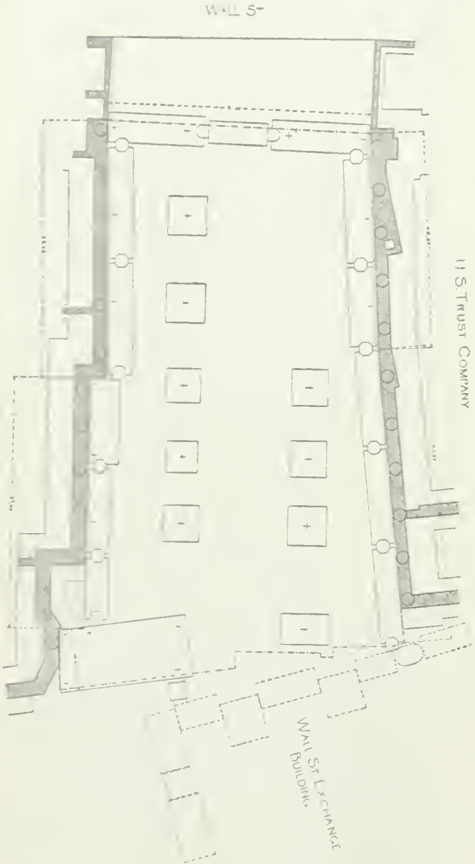

FIG. 2.

As shown in the accompanying plan (Fig. No. 2) this building is situated between the present United States Trust Company and the Mills buildings. Owing to the prevailing prices of Wall Street real estate, every inch of available space had to be utilized, with the result that the foundations of the new building practically "rub elbows" on either side with those of the old.

GEOLOGICAL DIFFICULTIES.

It is not generally understood that as we approach the southern end of Manhattan Island, the bed-rock slopes off lower and lower below the surface, so much so that at Wall Street it is 80 feet below the curb and at the Battery between 90 and 100 feet below. It might be mentioned in this connection that the rock appears at water line at about 14th street, and continues rising as we approach upper Manhattan, so that in building projects in this latter portion of the city, it is often necessary to blast away a miniature mountain before the site is even down to street level. It is due to this characteristic of New York's geological formation that the excavation for the great Pennsylvania Railroad depot has so often been termed a veritable "quarry." In

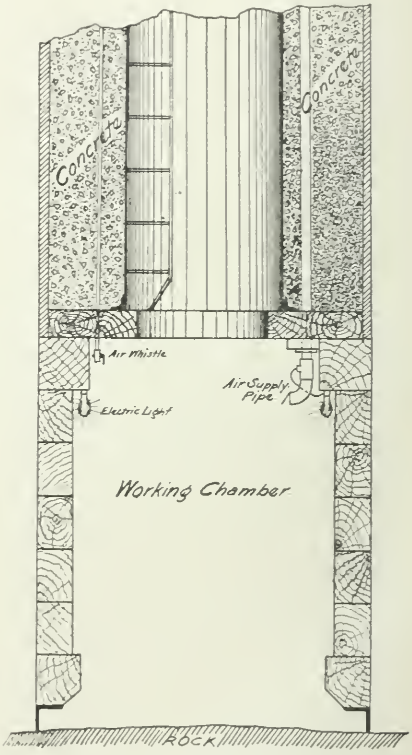

FIG. 3.

these cases the foundations are supplied by nature.

A STRIKING CONTRAST.

In striking contrast to such simple foundation problems, we have the case at hand. Foundations to be laid to bed-rock, through about 80 feet of quicksand and water-bearing strata which is already heavily loaded by adjoining ten-story buildings. In digging, water and soft mud is encountered but a few feet below the street level, and were this soft muck pumped out or removed by any of the old-time methods, more of this fluid material would enter the excavation from either side and the adjoining structures would settle and later collapse. The Foundation Company, to whom was entrusted the responsibility both of planning and doing this work, solved these problems by employing the Pneumatic Caisson Process, in conjunction with the Moran Air-Lock, an invention of their vice-president, Mr. Daniel E. Moran, C. E.

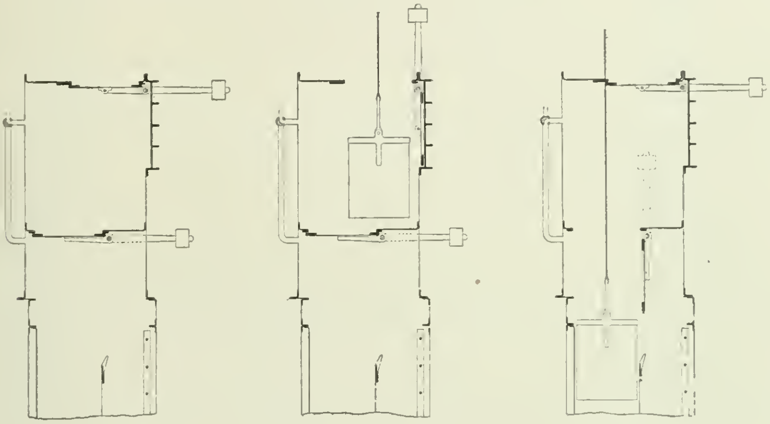

FIG. 4.

UNDERPINNING ADJOINING BUILDINGS.

The principle of the air-lock was used for the underpinning of the adjoining buildings as well as for the main part of the work. Cut No. 5 shows how work was begun even while the old building was being wrecked. Niches about five feet above the cellar floor, and five feet wide, were cut in the walls of the adjoining buildings with Box electric and Ingersoll-Sargent steam drills at intervals of about every six to nine feet. These were carried downward, through the old foundation, and through the sand under the foundation until the water line was struck. Then a six-foot length of riveted steel pipe, 36 inches in diameter, was jacked down into the sand, thereby employing the weight of the building in constructing the new underpinning. A downward opening door was installed at the top of this length, a second length was bolted to the first, and then a second downward opening door was installed, completing the miniature air-lock. As shown in Fig 5, compressed air was supplied to the bottom chamber and the work pushed lower and lower through quicksand or hard pan, as successive lengths of pipe were bolted to the top, and material excavated. When rock was reached the entire cylinder was filled with concrete, the steel pipe remained, and when the steel beams were placed, as shown in the left side of Fig. 5, the underpinning at that point was completed. Twelve of these concrete cylinders support the wall of the Mills Building, and eleven that of the United States Trust Company Building, as shown by the circles in the shaded portion of Fig No. 2.

Twenty-seven concrete piers constitute the foundation work proper, under the Trust Company of America Building. The remarkable speed with which these piers were sunk to bed-rock was made possible mainly from this one fact: The Moran air-lock allows the material excavated in caisson to be hoisted to the open air in one continuous haul, being handled but once in transferring from bottom caisson up to the dumping place, generally a truck. This feat was never possible with any other equipment until Mr. Moran took the lead and perfected his device shown in Fig. No. 4.

The square and rectangular spaces shown in Fig. No. 2 give the location of the concrete piers on the site of the Trust Company of America Building. In Fig. No. 6 is shown the four-boom traveler derrick, which is equipped with four double-drum Lidgerwood hoisting engines, and which effectively covered the entire area. It served to place the caissons (one of which weighed 20 tons and was 14x31x8 feet high) at their proper location. It also hoisted men and material in and out of the 27 working chambers. A typical caisson or working chamber is shown in Fig. No. 3.

Figure No. 6 shows the Moran air-lock in place near the top of the picture. The man stooping down on the ground is the gauge tender who keeps the pressure steady for the convenience of the men in the working chamber and the man at the air-lock communicates signals between the excavators and the engineers.

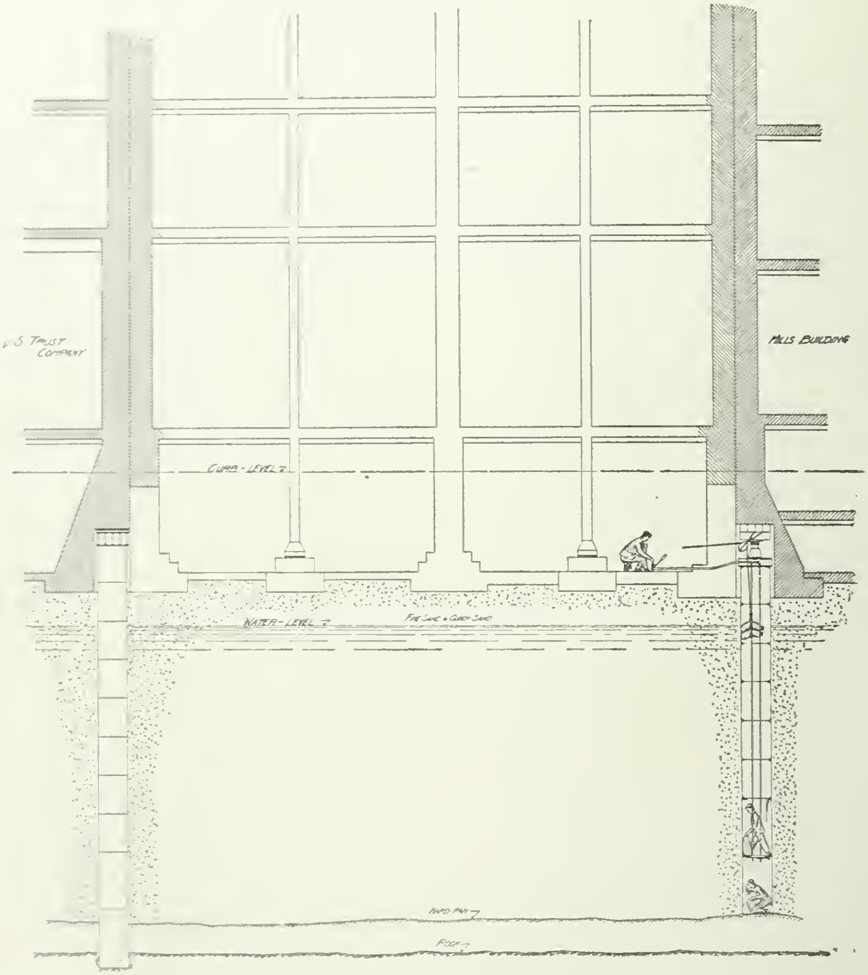

FIG. 5.

THE METHOD.

Having a general knowledge of the difficulties and of the apparatus to be used, and having finished the description of the underpinning, we shall take up the method employed in sinking the 27 great concrete piers through this soft soil to bed-rock without weakening the adjoining foundations. See Fig. No. 6.

After the wooden caisson proper had been located accurately, the workmen with picks and shovels excavated inside the open topped frame, which gradually sank of its own weight. When it had sunk to water level, which was but four to five feet below the street, preparations were made to apply the compressed air as follows: The open top of the caisson was roofed over temporarily and the first ten-foot section of the steel collapsible working shaft was joined to the upper part of the caisson as shown in Fig. No. 3. Section after section were added and then a Moran Air Lock as shown in Fig. No. 6. Then a section of temporary wooden cofferdam was built and fitted to the outside of the caisson so as to extend its sides upward several feet This was to act as a false work for retaining the successive thin layers of concrete dumped into the annular space inside the cofferdam and on the roof of the caisson surrounding the working shaft, as will be noticed in the right hand side of section in Fig. No. 6. After the first ten feet of concrete had hardened, a second cofferdam

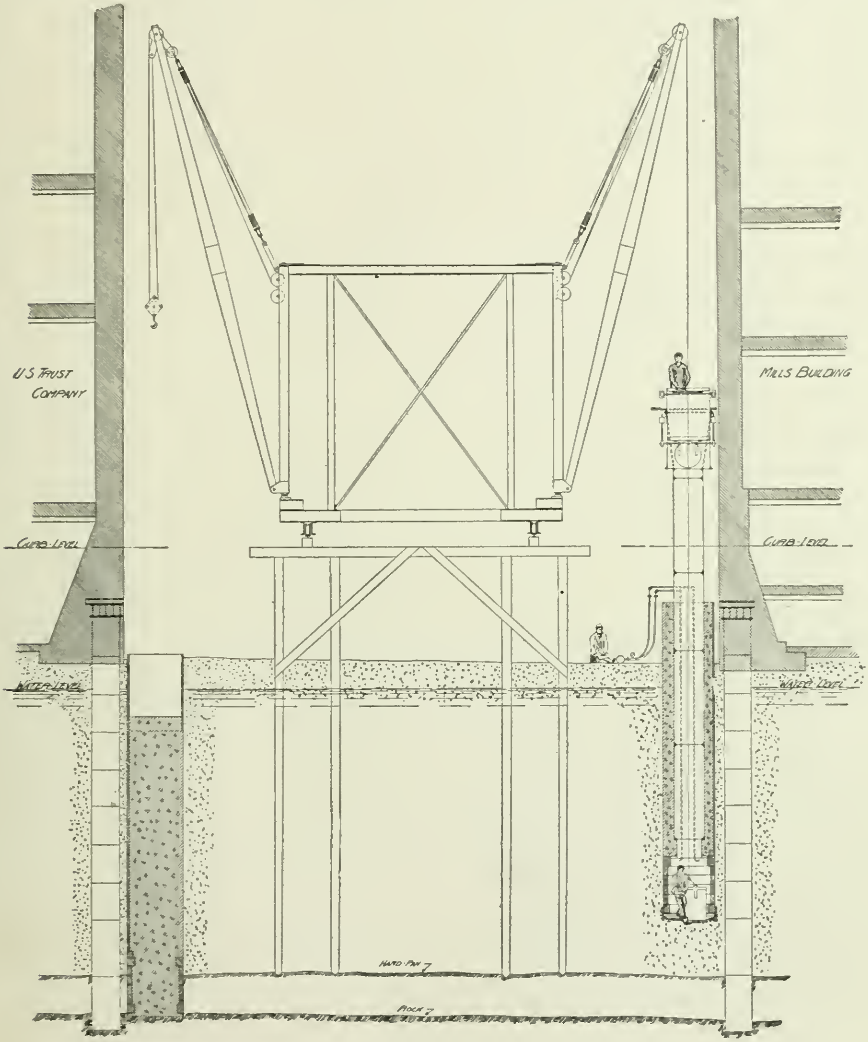

FIG. 6.

was fitted in a higher position, and the concreting continued, the first cofferdam being later removed and used as the third. One gang of men and one mixer could move from cofferdam to cofferdam, applying a two-foot layer in each, so that by the time they returned to the first one it was hardened enough to receive its next layer without distorting the sheeting. So nearly the full height and full weight of the finished pier was used to force the caisson down to its final resting place on bed-rock, as rapidly as the excavating could be done by the men inside. Alpha Portland cement was used on this job in a 1 to 2½ to 5 mixture.

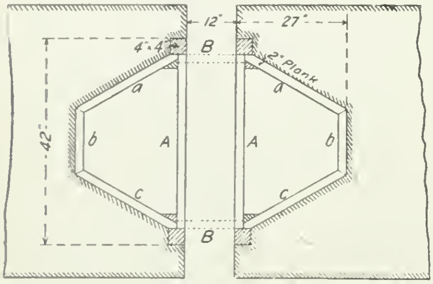

FIG. 7.

Referring again to Fig. No. 3, it will be noticed that the lower edges of the caisson sides are sharpened to form the "cutting edge" of the caisson, since they follow the level of the excavation and are pressed down by the great weight above. The contracting firm have prepared special two-ton C. I. weights, which can be piled on top of the concrete pier to further sink it in case the "skin friction" on the sides is too great for the pier to sink of its own weight.

During this process three eight-hour shifts of the laborers were digging out material in the caisson under a pressure of from 18 to 24 pounds per square inch. This material was shoveled into buckets and hoisted up through the working shaft and the air-lock out to the atmosphere, all in one continuous lift as previously explained in connection with Fig. No. 4.

FILLING IN THE CONCRETE PIERS.

When bed-rock is reached, it is leveled off and, still under compressed air, the concrete is lowered into the caisson and rammed in place. The entire caisson is filled to the top, the temporary roof removed, and as the men retreat up the tube they unbolt and remove a section of the collapsible tubing and hoist it up for use in sinking another caisson. Gradually the entire space previously used as a passage for men and material in and out of the working chamber or caisson, is filled with concrete, thus making the pier one solid monolith of concrete from bed-rock to the column base. This is shown on the left side of Fig. No. 6.

Referring again to plan view, Fig. No. 2, it is seen that these piers are sunk end to end with only 12 spaces between, and that the chain of piers around the entire site is made perfect by *welding or bonding* between the ends of each pier. This keeps the water from the surrounding soil from entering either the basement or sub-basement of the building. The method is as follows: In Fig. No. 7 will be seen the end faces of the two adjacent piers. The semi-octagonal grove shown in the faces was formed at the same time that the cofferdam was put around the top of the caisson. The wooden false work served as a "core," displacing the concrete from top to bottom of each end face of the piers. As soon as two adjacent caissons were ready to be welded or bonded the space bounded by ABAB was excavated. At the same time the laborers would tear off the boards AA, saw them into the shorter lengths BB, and nail them in position BB, as shown in dotted lines. The space between the piers thus had become octagonal in shape and was carried down the few feet to the water level. The planks abc abc were removed. A four-foot length of steel cylinder 30 inches in diameter was placed in the opening and the space between it and the surrounding concrete and boards BB, was filled in with concrete and made air tight. An air-lock was bolted to the top of this cylinder and the workmen excavated the material between A and B, tearing out all the lumber as they went down, and hoisting all the material to the surface except what was needed for completing the boards BB down to the top of the caisson. This octagonal well was then filled to the top with concrete under pressure and the bond was complete. When these connections between piers were completed on the north, east and west borders of the building site, it was only necessary to make the bond with the foundation piers of the Wall Street Exchange building on the south (put in by the same contractor to bed-rock) in order to fully enclose the lot and prevent future flooding of the cellars, which reach to a depth of near 40 feet below the water level. It will be seen from Fig. No. 2 that this was done without expense of sinking a separate line of caisson on that side.

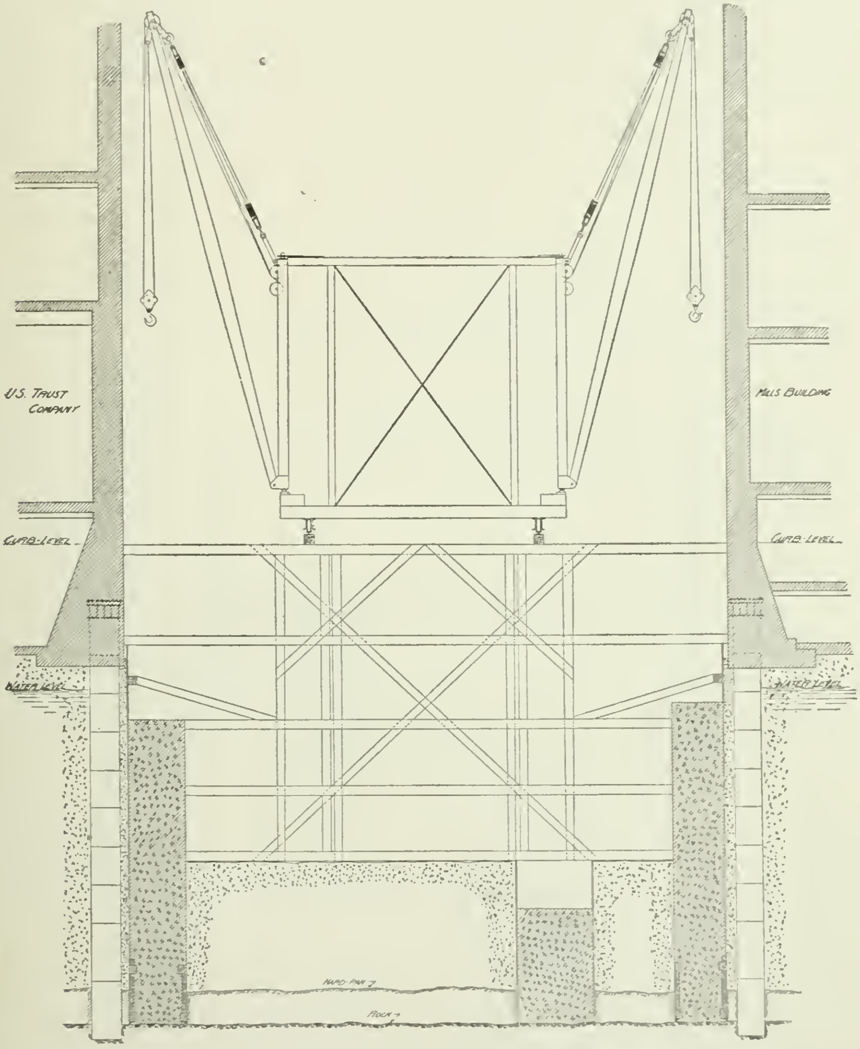

FIG. 8.

Another advantage in this *solid wall* type of bonded foundation construction, is that the piers in the center of the lot can generally be sunk without the expense of the compressed air method, for there is little danger of any water seeping in from the outside, and therefore of weakening the other buildings.

At this stage of the job, the cellars can be safely dug, during which work the shoring of the neighboring building walls is shown in Fig. No. 8. Fig. No. 9 illustrates the appearance when all the substructure is completed and the cellar made ready for installing engines and boiler. The general class of work of which this job is merely one branch, is *Civil Engineering in water or water-bearing strata,* including mine shafts in wet or marshy lands, bridge piers, sea walls and tunnels. The Foundation Company, of 35 Nassau Street, New York, were the contractors for the work described above.

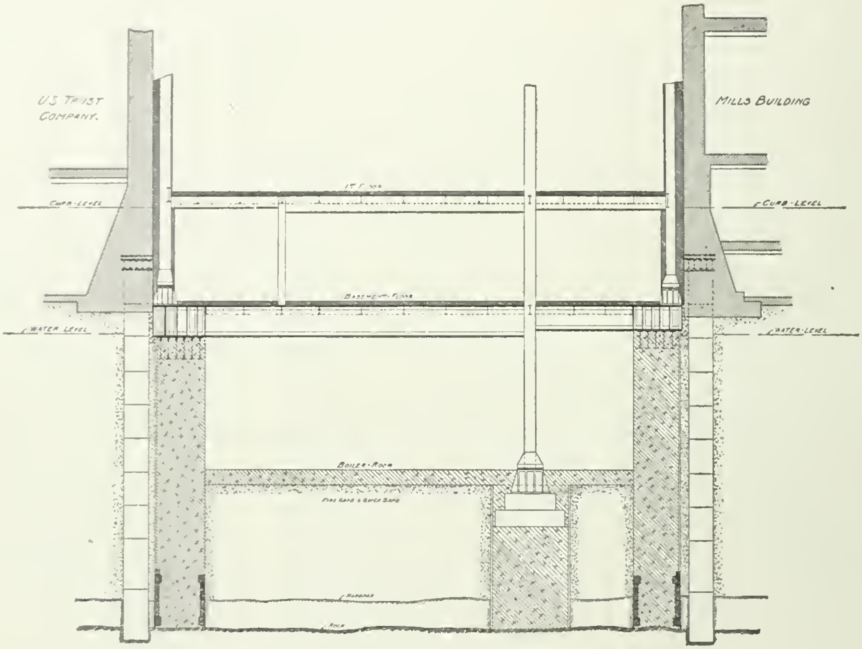

FIG. 9.

POWER prices vary widely. As a rule, power from hydraulic installations is cheapest, and power developed from coal that must bear the expense of a long railroad haul is the dearest. According to a recent report by the Hydro-Electric Power Commission appointed by the Ontario Government $12 per horse-power year may be assumed as the cost of developing high-tension power at Niagara Falls. Transformed into low-tension power and delivered to sub-stations throughout the province, the cost would be from $15 to $35, varying with the amount, distance and load. The cost of distribution from the sub-stations to the individual consumers would vary from $2.51 to $24.74 per H. P. year, according to the amount and the distance. The annual cost of twenty-four-hour steam plant power per brake horse-power, with $4 bituminous coal, according to the same report, would vary, with the character of the plant and the amount of power developed from $41.11 to $180.76. Under the same conditions, it is estimated in this report that producer gas power would vary in cost from $34.66 to $90.02. For ten-hour power, developed from producer gas, the cost would vary from $20.46 to $53.48; for steam-power from $22.47 to $91.16.

TRAVELERS have noted that Damascus blades are made only when the wind is from the north. The experiments of M. Anozoff were suggested by this hint, and have consisted in hardening steel instruments by cooling them in a powerful current of compressed air instead of quenching in water. The trials indicate that for very sharp tools this method is superior to any other. The effect varies with the thickness of the mass to be hardened, and increases with the coldness of the air and the rapidity of the stream.

SOME IMPORTANT ELEMENTS OF ECONOMY IN THE STRAIGHT LINE AND DUPLEX TYPES OF COMPOUND AIR COMPRESSORS*

By Lucius I. Wightman.

The act of compressing air in any of the usual types of air compressors, and of expelling the air from the compressor cylinder at the pressure desired, throws a constantly varying resistance upon the compressor piston. At the beginning of the stroke, the cylinder being filled with air certainly not above atmospheric pressure, the resistance to the advance of the piston is zero. The pressure, however, begins to rise at once and the corresponding resistance against the piston increases, and in an increasing ratio, until nearly the end of the stroke when the required pressure is reached, and the remaining distance is traversed by the piston against a practically uniform maximum pressure. Upon the return stroke, the compressor cylinder being double-acting, the resistance is again zero at the beginning of the stroke and maximum for the latter part of it.

ADVANTAGES OF STEAM COMPOUNDING

The advantages of compounding in steam engine practice everywhere are so familiar as to require not even a repetition here, but its special value in air compressing practice seems not to be fully appreciated. In view of the number of steam-driven compressors in use which are neither compounded nor condensing, it seems that it is not generally understood that, while a saving of 10 to 15 per cent of the power cost is possible at the air end of the compressor by compounding, a saving of about double that percentage in fuel cost—20 to 30 per cent—is easily possible by compounding the steam end of the same machine. If compound compression is economically practical, why neglect a saving twice as great possible by compound steam expansion?

THE PECULIARITIES OF COMPRESSOR OPERATION

This neglect is especially remarkable in view of the fact that the air compressor embodies load conditions which make the compounding and condensing of steam cylinders even more economically desirable than in general steam engine practice. Compound steam-driven air compressors can show better results than compound stationary engines for power purposes, and for a very simple reason. To get all the economy possible from the steam, it must be admitted to the first cylinder in just such quantity that when it is finally expanded into the low pressure cylinder, its pressure there shall be such as to avoid excessive expansion and consequent heavy condensation losses. This means, of course, the admission of the same quantity of steam per stroke, for each stroke, implying a cut-off constantly fixed very close to the right point. This is entirely impossible with the stationary engine, where the constant speed under varying load must be maintained by a constantly changing cut-off, this cut-off being automatically controlled by the governor, and necessarily having a wide range to meet load conditions. There can be only one *best* point of cut-off, and departures from that necessarily impair the ultimate economy.

THE LOAD PER STROKE CONSTANT IN THE COMPRESSOR

In the case of the air compressor the load is constant per stroke, for the same delivery pressure must be maintained; and the cylinders can be so proportioned and the cut-off so set as to secure and maintain the best results. The governing variations of the steam-driven compressor are as to speed only, and, with air pressure constant, the changes in speed are made either by a very slight change of cut-off, or with a throttling governor. In the latter case the slight "wire drawing" is about offset by the resultant superheating of the steam. As a result of these conditions the compound compressor can be made to work close to its best economy at all times.

STEAM PRESSURES FOR COMPOUND COMPRESSOR CYLINDERS

The steam pressure used has an important bearing upon the ultimate economy. Within practical limits, the higher the pressure, the better the results. Gauge pressures of 125 to 150 pounds are now quite common in new installations; but, in air compressor practice, steam compounding is advantageous with steam at 80 pounds condensing, or 90 pounds non-condensing, though this may not be at all true in general power practice. When, as is often the case where compressors are used, water is costly, the smaller amount required by the compound is an argument for it; and the ultimate cost of the arrangement is also largely offset by the reduced cost of boiler installation and operation, due to the lower steam consumption.

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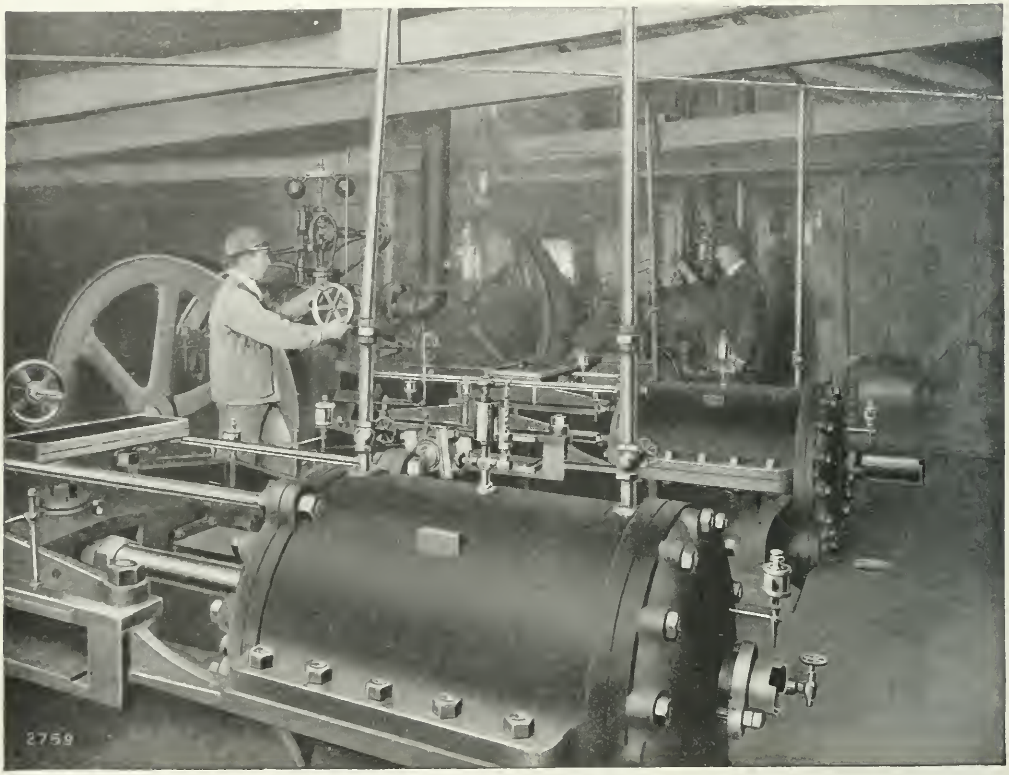
*Illustrations reproduced by courtesy of the Ingersoll-Rand Company of New York.

STRAIGHT LINE AND DUPLEX COMPRESSORS

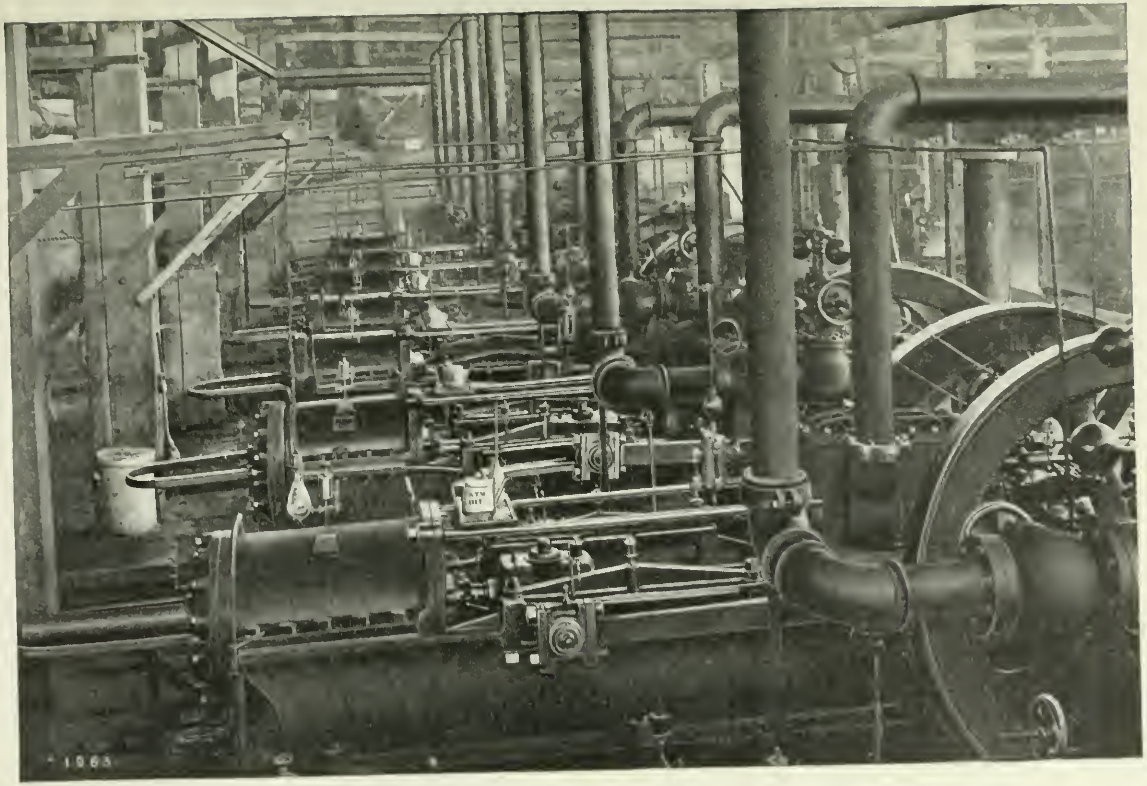
It is unnecessary at this point to enter into a discussion of the phenomena of the application of power to resistance in the present work. It will be enough to mention and to briefly draw the distinction between the two standard types of air compressors, designated as the straight line and duplex. In the former, steam and air cylinders, whether simple or compounded, are arranged in a straight line, and power is applied to resistance through the medium of one long piston rod. In the duplex machine there are two elements, set side by side, each made up of a steam and an air cylinder, and each element in effect a straight line machine. However, the cranks of these two sections are set at an angle of 90 degrees, or one-fourth part of a circle, on the shaft. The primary object of this quartering crank arrangement is to secure a more uniform rotation effect, and to improve the regulation qualities of the machine by making it easier to run at slow speeds through the mutual assistance of the two sides. The straight line compressor may have two three, or four cylinders, but they must all be arranged in a straight line or "tandem" to one another. The duplex compressor must have four cylinders.



A TYPICAL "STRAIGHT LINE" INSTALLATION.
Two single stage machines used in driving the Lookout Mountain Tunnel of the Southern Railway, Tennessee. Steam cylinders, 20 inches; air cylinders, 22¼ inches; stroke, 24 inches.

THE RELATION OF POWER TO RESISTANCE IN STRAIGHT LINE COMPRESSORS

This distribution of resistances in the act of compression in the air cylinder is precisely the reverse of the development of the power in the steam cylinder. There the pressure is maximum at the beginning of the stroke and practically uniform until cut-off occurs and then the pressure rapidly falls all the way to the end; so that in any compressor of the straight line type the steam power is in excess of the



A LARGE "STRAIGHT LINE" COMPRESSOR INSTALLATION FOR A CONTRACTOR'S PLANT

An installation of eight 24-inch stroke machines in the power house of H. S. Kerbaugh, Inc., at Safe Harbor, Pa., used in building the low grade "cut-off" of the Pennsylvania Railroad along the Susquehanna. This is the largest railway contract ever handled by compressed air from a central plant, the work covering 9 miles of solid rock cut and employing 250 rock drills and 42 well drilling machines operated by compressed air.

work to be done at the beginning of the stroke in either direction and inadequate to overcome the resistance of the air at the other end of the stroke, except with the assistance of flywheels.

The pistons, by means of the crosshead and connecting rods, act through the crank upon the rotation of the flywheel, the excess of pressure causing the wheels to acquire momentum at the beginning of the stroke and to give off this acquired momentum at the end of the stroke in overcoming the excess of the air piston resistance. As soon as the crank passes the center, the machine again feels the impulse of the full pressure of steam, with no load at first to take up this power in the air end.

HOW THE DUPLEX COMPRESSOR MEETS THESE CONDITIONS

Attention is now called to the duplex compressor, in which the operating conditions are in decided contrast to those just sketched, and in which the most objectionable of the conditions are minimized or altogether eliminated, and various points of practical advantage are secured instead.

A duplex air compressor, as already stated, is, in essential effect, a combination of two straight line machines so far as the steam and the air cylinders are concerned, with a single crank shaft and a flywheel in the middle of it serving for both, there being a single connecting rod for each side and a single crank on each end of the shaft.

THE ADVANTAGE OF QUARTERING CRANKS

The first special feature of advantage of the duplex machine is in the arrangement of the cranks in relation to each other upon the ends of the shaft. These are set with one of the cranks a quarter of a circle in advance of the other, the result of which is to so time the movements of the pistons on the two sides of the machine that one will be at nearly mid-stroke when the other is at the beginning or the end of its stroke. The two sides thus alternately help each other over the hard places, and, while not under nearly as great obligation to the flywheel, their action is much steadier and so free from excesses of pressure over resistance, or of resistance over pressure, that the rotation is more uniform. The practical limit of speed is lowered to perhaps one-quarter of what it was before, so that, if the cut-off on the steam cylinder is properly set, the machine may be made to automatically stop and start itself and to run at any speed down to the lowest, as the air consumption may require. All waste of power and all wear of parts consequent upon keeping running above "centering point" when not delivering any air, will be entirely avoided.

THE RELATION OF POWER TO RESISTANCE IN THE DUPLEX

Suppose that one of these duplex compressors is in regular operation, with the pistons on one side—say the near side— just beginning their stroke, and with the great excess of pressure behind the steam piston, and the very low resistance before the air piston as we have described the situation in the straight line machine. It happens that precisely at this time, by the 90-degree arrangement of the cranks, the pistons on the other side of the machine are nearly in the middle position; the pressure behind the steam piston on that side has begun to fall, while the pressure before the advancing air piston has risen, so that pressure and resistance are approaching a balance, and to complete the stroke some assistance will be required. In this case, instead of getting this help out of the flywheel, it is secured through the shaft and cranks from the pistons on the near side of the machine which, just at this time, have power to spare. In the same way throughout the rotation of the crankshaft and the double strokes on the two sides of the machine, this reciprocal action of the one side upon the other is not only secured, but the excess in either direction is much reduced; and the calls upon the inertia of the flywheel to keep things going are much less, and even with less flywheel weight the running is much steadier.

The pressure relations in the four cylinders of the duplex steam driven compressor at the four quarters of the stroke are graphically shown in the four diagrams following. For the sake of clearness, pressures on only one side of the pistons have been considered in these diagrams. The effect of back pressure in the steam cylinders on the other side of the steam pistons and the effect of suction pressure (if such a term may be used) on the other side of the air pistons, is neglected. These two elements in no way affect the theory of the relation of power to resistance on the pistons as indicated.

Fig. 1 shows the instantaneous pressures at the beginning of a revolution. In the lower cylinders there is no power and no resistance; in the upper cylinders there is excess power and a small resistance. This excess power will be applied in carrying the compressor over the center of the lower half.

Fig. 2 shows the conditions a quarter of a revolution later. Here, in the two upper cylinders minimum power is being applied to maximum resistance at the end of the stroke; in the two lower cylinders excess power is being applied to small resistance at midstroke, the surplus pressure acting to carry the compressor past the center of the upper cylinders. power in the lower section will carry the compressor over the center of the upper section and admit steam to the upper cylinder, which will be applied against the increasing resistance in the lower air cylinder.

MORE UNIFORM STEAM CYLINDER PRESSURES IN COMPOUNDING

It is an interesting thing that when four cylinders are adopted in a duplex, to secure a more uniform rotation effect and to make it possible to keep running at the lowest speeds, the compounding of the cylinders helps to promote the original purpose of the duplex arrangement. At the steam end, because of the higher terminal, the variation in working pressure is less. The result is that the effective pressure for the stroke is more uniform and continuous, and the rotation effect produced from the beginning to the end shows less difference than when the steam is used in a single cylinder. The difference of pressures in the low pressure cylinder is less for the same reason.

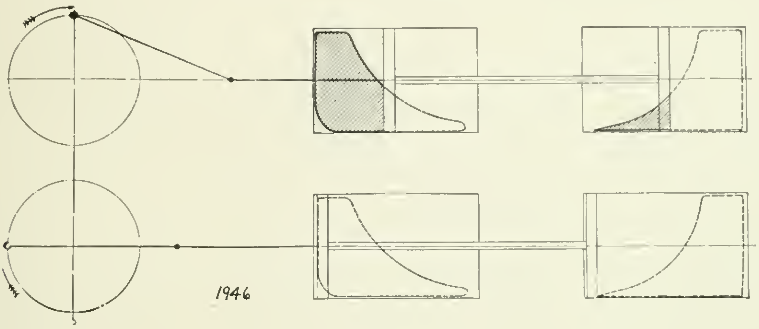


FIG. 1.

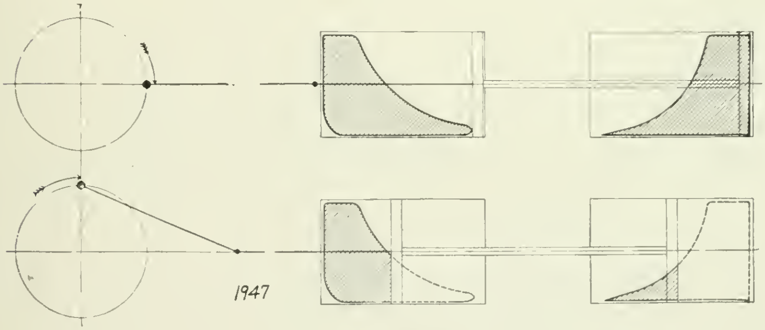


FIG. 2.

Fig. 3 shows the conditions on the return stroke, a quarter of a revolution later. In the two lower cylinders at the beginning of the stroke, power and resistance are *nil;* in the two upper cylinders the power exceeds the resistance and the excess power carries the machine past the center in the section indicated by the lower cylinders.

Fig. 4 shows the conditions after another quarter revolution has been made. Here the conditions are exactly the same as those in Fig. 2, but in reverse relation. The excess

CONDENSATION LOSSES REDUCED BY STEAM COMPOUNDING

Aside from this reduction in range of cylinder pressures, the differences in temperatures are a powerful element in economy. These two features will be more clearly understood by a brief consideration of a specific case.

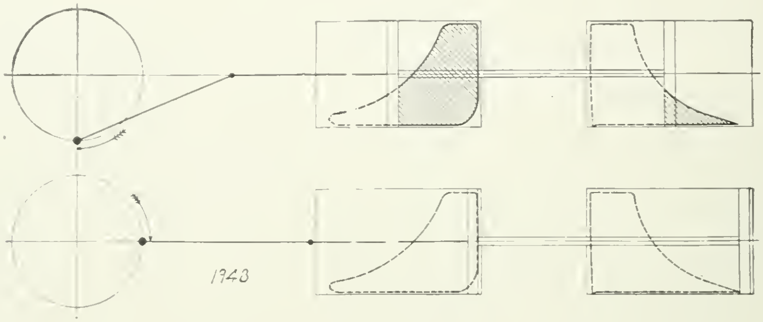


FIG. 3.

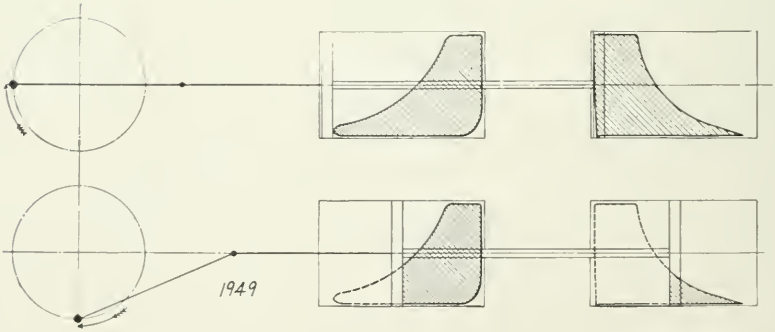


FIG. 4.

Assume that the initial steam pressure is 145 pounds gauge, or 160 pounds absolute, and that a condenser gives a terminal cylinder pressure of say, 10 pounds absolute. Ignoring for the sake of clearness the effects of clearance, condensation, etc., there are seen to be 16 expansions of the steam. In compound steam cylinders, properly proportioned, this means 4 expansions in each cylinder. In the high pressure cylinder, the initial steam pressure will be 160 pounds and the terminal 40 pounds; the initial temperature will be 363 degrees F., and the terminal 267 degrees F. The difference of pressure is thus 120 pounds and in temperature 96 degrees. In the low pressure cylinder initial and terminal pressures will be 40 and 10 pounds, respectively, corresponding to temperatures of 267 and 193 degrees F. The difference in pressures is here 30 pounds and in temperatures 74 degrees.

If this expansion had been applied in a single cylinder, the range of pressures would have been 150 pounds and of temperatures 170 degrees F. Evidently the use of compound steam cylinders in this case reduces, by approximately one-half, the cooling effect to which cylinder walls, ports, valves, etc., were subjected by the drop in temperature through expansion. The steam consumption in the former case would have been correspondingly less, and the effect to temperatures on steam economy is apparent. If a condenser had not been used, the range of pressures and temperatures would not have been so great, but, relatively, as between compound and simple cylinders, the same comparison would hold.

TO BE CONCLUDED.

COMPRESSED AIR ILLNESS OR CAISSON DISEASE. *

A PHYSIOLOGICAL AND CLINICAL STUDY.

By Thomas Oliver,
M.A., M.D., L.L.D., F.R.C.P.
Professor of Physiology College of Medicine and Physician to the Royal Infirmary, Newcastle-upon-Tyne.

(Concluded from February.)

WHAT ARE THE SYMPTOMS DUE TO?

Inside the caisson the men are working under abnormal conditions. The pressure is high, the work is hard, and the men are dependent for the air they breathe upon what is pumped into the shafts by the engines. One pound of air pressure, as already stated, is required to displace 2 feet four inches of water so that where men are working 70 to 80 feet below high water level mark they are under a pressure of not less than 35 lbs. to the square inch. As excavation proceeds and the caissons sink, the greater is the pressure required. The men are more liable to compressed air illness as the depth increases and the pressure rises; the same thing is noticed when the shifts are longer, also the less pure the air and the smaller the quantity of fresh air sent into the caisson. On the Tyne most of the cases of compressed air illness occurred when the men were on the night shift. Why this should be it is difficult to say, for the length of the day and night shift is the same. Some of the cases occurred when the men were *not* working at *maximum* pressures at all, but when they were digging through a layer of soft coal in the bed of the river and from which H_2S escaped into the caisson. At the Forth Bridge, Dr. Hunter noticed that the men suffered most when they were removing the soft silt on the bed of the river. Not only must pure air be sent into the caisson, there must be plenty of it, and provision made for the ready escape of the surplus air by the bottom of the caisson, so as to secure adequate ventilation.

In studying the effects of very high pressures of atmospheric air, the part played by the oxygen tension must not be lost sight of, for when breathed under very high pressure oxygen becomes a poison. It rapidly induces toxaemia. Paul Bert found on exposing dogs to high pressures of oxygen, and rapidly decompressing them that the animals became convulsed, and on analysing the gases of the blood during the convulsions he found that the carbon dioxide had fallen to 14.8 and 10.5 per cent.

He therefore concluded that excess of oxygen arrested metabolism. In a series of experiments which I lately carried out at the Newcastle College of Medicine with my former house physician, Dr. Parkin, I subjected mice to high pressures of oxygen 10 atmospheres and upwards. When the animals had been exposed for 5 or 6 minutes the breathing usually became hurried, and shortly afterwards the animals would fall to one or other side in a state of coma, the pupils became dilated, and the animals died in convulsions. They died asphyxiated probably because the CO_2 of the tissue was not removed, or it might be that the oxygen itself acted as a poison. One effect of the exposure of animals for a few hours to high pressures of oxygen is pneumonia. There are capillary haemorrhages and the alveoli of the lungs become filled with an inflammatory exudate, the lungs become semisolid as in the early stage of pneumonia. To such an extent are the lung lesions developed under these circumstances that Prof. Lorrain Smith believes the inflammation of the lungs to be the cause of caisson disease. Against this must be placed the fact that some of the worst cases of compressed air illness that I have seen occurred when the men were not working at high pressures, and when therefore the oxygen tension was not great. Besides the major part of the symptoms of caisson disease occurs on the side of the nervous system, and not in the lung, they are too sudden for that. The symptoms that arise during exposure to high oxygen pressures are not so much due to the total quantity of oxygen in the blood as to the tension of the gas in solution. At any rate animals behave differently when exposed to the same pressures of oxygen and compressed air. When I had exposed mice for 6 minutes to 10 atmospheres of oxygen they became convulsed, but they could be exposed to much higher pressures of atmospheric air for similar length of time without convulsions occurring, probably because the length of time was not sufficient for oxygen poisoning to occur. With such high pressures of atmospheric air as 20 atmospheres or 300 lbs. to the square inch, and an exposure of the animal to such for 15 minutes, I found that invariably no symptom occurred until decompression was rapidly induced. The animals then became convulsed owing, not to oxygen poisoning, but to the setting free of bubbles of air from the gas that had been dissolved in the blood. The consequences therefore of the exposure of animals to high pressures of oxygen and of atmospheric air are not exactly the same. The convulsions of oxygen poisoning come on when the animal is in the pressure chamber, and are therefore the result of a toxaemia, but in the case of compressed atmospheric air they develop only after the animal has been rapidly decompressed and taken out of the chamber, and are due to frothing of the blood in the heart, and small blood vessels. During the time a workman is in a caisson the circulation of the blood in his vessels remains practically the same as if he were outside, but the air that he is breathing becomes dissolved in his blood in proportion to the pressure, and since four-fifths of the air he is breathing is nitrogen it is this gas which forms the largest constituent of the gases dissolved in the blood and which is afterwards liberated during rapid decompression. When atmospheric air contains excess of carbonic acid, or has become accidentally polluted by even small traces of carbon monoxide or sulphuretted hydrogen there is increased danger to life from toxaemia. So far as having been exposed to high atmospheric pressures is concerned the effect of sudden decompression is appropriately illustrated when the cork of a soda water bottle is drawn, there is effervescence. After having exposed pithed frogs to high oxygen pressures, say 300 lbs., and having suddenly decompressed them, I noticed that while no apparent effect was immediately produced in the circulation yet in 2 to 3 minutes afterwards the stream of blood was observed to slacken and to oscillate, now backwards, now forwards, that a bubble or two of gas appeared inside the capillary towards the venous side, that these bubbles of air coalesced and ultimately filled a considerable portion of the blood vessel. The circulation thereafter ceased in that vessel for it was occupied by air. Occasionally a vessel ruptures, and there is escape of blood into the surrounding tissues. On making microscopical sections of the brain and liver of some of the animals that I had exposed to high pressures of atmospheric air, which had been rapidly decompressed, and had died in consequence of the rapid decompression there can be seen numerous circular spaces in the brain the result of extreme dilation of capillary blood vessels, while in the liver in addition to large spaces that had evidently been filled with air, there are several excessively dilated blood vessels, haemorrhages and tearing of the liver tissue.

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* Abstract of a Lecture delivered to the "Genootschap ter Bevordering van Natuur-, Genees- en Heelkunde", Amsterdam.

Caisson disease is therefore in my opinion the result of mechanical causes, and not of toxaemia, and yet some influence must be exerted as previously stated by the presence of impurities in the air inside the caisson, and the hard character of the work the men are engaged in. Since, however, the symptoms of genuine caisson disease occur in men who have been working in compressed atmospheric air free from impurities, and can be produced experimentally in animals under similar circumstances I am of the opinion that frothing of the blood or the sudden liberation of gas in the blood vessels is the chief cause of compressed air illness, and that in most cases it is due to the men spending too little time in the air lock during decompression. Pol and Wattelle considered the symptoms to be the result of the blood being driven by the compressed air from the peripheral parts of the body to the internal organs, and causing congestion of these organs. Dr. Andrew Smith believes them to be the result of a congested state of the capillaries of the nervous system and that the distended blood vessels do not recover their elasticity quickly enough when the compression is removed. Corning, who gained his experience of caisson disease during the construction of the tunnel under the Hudson between New York City and Jersey, believes the symptoms to be the result of the sudden rush of blood to the periphery during decompression, and the consequent rapid diminution of the circulation in the central parts of the body. Of the two theories therefore advanced to explain caisson disease the hydraulic or distended vessel theory and the pneumatic or the theory of the liberation of gases in the blood there can be no doubt as to which is the more likely.

Experimental investigation, clinical experience and pathological fact all lend support to the opinion that caisson disease is the result of the setting free of gas in the blood and in the fluids of the tissues. It is to Paul Bert we are indebted for having placed the pneumatic theory upon a scientific basis. For some reason or other the small blood vessels in the lower portion of the spinal cord have to bear the brunt of the liberation of gas when decompression is too rapidly performed, hence the common sequence, paraplegia. When decompression on the other hand is effected very gradually nature provides for the escape of the gases, previously dissolved in the blood, little by little through the lungs. It is this silent and slow escape of gas through the lungs that is the saviour of the worker in compressed air. If we take the view that caisson disease is the result of mechanical causes, viz: too rapid decompression, then we are dealing with a malady that can to a large extent be prevented.

Breathing through the lungs is the outward sign of a deeper or "internal" respiration known as the respiration of the tissues. During internal respiration oxygen is removed from the haemoglobin of the red blood corpuscles by the tissues and carbon dioxide is given up by the tissues to the blood. Professor Merget, of Bordeaux, holds the view that there is a gaseous atmosphere in our tissues, and that this is the medium of respiratory interchange in the same manner as the atmospheric medium stands related to pulmonary respiration. He therefore maintains that in compression "the gases in the blood are diffused into the tissues until their tension has become equal to the tension of the compressed air." It is upon this equilibrium that freedom from symptoms depends. During rapid decompression this equilibrium is broken, and as the atmospheres of the tissues have still a higher tension than that of the air which was previously compressed they increase in volume and forcibly separate the tissues that surround them, causing accidents by lacerating the tissues or by leading to the development of intravascular bubbles of air or emboli. It takes a longer time for the tissues to become saturated with gas than it does the blood, hence short shifts of work are not nearly so dangerous to men as long shifts, for the less is the blood saturated with gas during compression and the smaller is the quantity of gas set free during decompression.

PREVENTION AND TREATMENT OF CAISSON DISEASE Since caisson disease is largely the consequence of the liberation of gas in the blood and tissues owing to the time spent in decompression being too short, it is the duty of employers to see that the time spent in decompression is adequate and that the regulations are effectively carried out. The length of time spent by the men in the air lock will vary with the pressure they have been working in and the length of the shift. One minute for every 5 lbs. of pressure is the time allowed at the works on the Tyne. This is found to be quite adequate but the time might be slightly extended, for if anything, it is on the side of brevity. Nearly all physiologists admit that decompression is a procedure over which there ought to be no hurrying, and yet there is no unanimity in regard to their recommendations. Francois recommends, for example, 6 to 8 minutes for each increment of pressure equal to 1 atmosphere; Foley, 1 minute for each atmosphere; Barella 10 minutes per atmosphere, while Triger recommended only 7 minutes for the whole act of decompression irrespective of pressure. Paul Bert is in favor of short shifts and of extremely slow decompression and he recommends heating of the air lock. Hill and Macleod are of the opinion that when men are working under 30 lbs. pressure for 4 hours at a time the decompression period should be 30 minutes to 1 hour; 45 to 60 lbs. pressure and with 4 hours shift that the time spent in decompression should be 1 to 2 hours. It would be difficult to keep workmen in the air lock all this time undergoing slow decompression, for the air inside is extremely cold, and the air locks can not be readily heated and ventilated; besides the air locks are usually too small. No man who is an alcoholic should be allowed to work in a caisson, nor anyone who is suffering from nasal or laryngeal catarrh, or who is the subject of weak heart or diseased lungs. Young men between the ages of 20 and 30 whose tissues are still elastic do the work better than those of maturer years, also men who are of rather slim than stout build. All workmen should be medically examined when taken on for the first time. The Dutch regulations require that the men should be seen daily by the medical officer in charge, and this is a step in the right direction.

Ventilation of the caissons is most important. It is difficult to say under what limits of pressure men can work in caissons consistent with safety and effectiveness. The greater the depth that is reached, and the higher the pressure, the shorter must be the shifts since the longer there is exposure to high pressure of compressed air the greater becomes the risk of oxygen poisoning. It is possible to subject animals to 8 atmospheres of air or 120 lbs. pressure for 5 hours every alternate day for a period of safety, so long as plenty of time is spent in decompression e. g. 1 to 2 hours. I exposed a mouse to 20 atmospheres of compressed air i. e. 300 lbs. pressure for 10 minutes, but the pressure had to be lowered from time to time on account of muscular tremors the result of oxygen intoxication. Although 15 minutes only were spent in decompression of this animal and the mouse on its removal from the chamber seemed indisposed and unwilling to move, yet the animal has remained well ever since. H. Von Schrotter 1) has suggested that caisson workers should wash out from their blood and tissues the nitrogen absorbed during their work in high air pressures by breathing pure oxygen for 5 minutes before undergoing decompression. Theoretically the recommendation is sound and it has been proved experimentally to be efficient in preventing death from air embolism although the method requires consideration and attention. A rat exposed for 5 minutes to 20 atmospheres of oxygen will have very few bubbles of gas in its blood after rapid decompression; it will be convulsed, but it will live, while another rat exposed to similar pressure of atmospheric air will be instantly killed by rapid decompression and numerous bubbles of air will be found in its blood and tissues. Schrotter's recommendation might be adopted with safety for low pressures, say anything under 50 lbs., but above this we have to remember that oxygen itself becomes a cause of danger by producing toxaemia and inflammation of the lungs. Below 50 lbs. pressure decompression, if slowly and gradually carried out, can accomplish all that is required so far as the safety of the workmen is concerned.

RECOMPRESSION.

Workmen on coming out of the air lock are often seized with severe muscular pains which experience has taught them will be relieved if they, will at once re-enter the air-lock, and allow themselves to be again compressed and afterwards very slowly decompressed. Recompression has therefore come to be a recognized method of treating caisson disease. By physiological experimentation on animals I have confirmed the value of recompression. There ought to be therefore at every large engineering undertaking where caissons are employed a medical lock into which the workman could be placed immediately they show symptoms. By this means not only could the muscular pains be treated but possibly more severe symptoms as well. In the case of a frog which I had subjected to a pressure of 20 atmospheres, and rapidly decompressed, and whose respiration had ceased the breathing became re-established under the influence of recompression. The medical lock should be large enough to accommodate 3 or 4 men of whom 2 could be in the recumbent position, and the chamber should be capable of being warmed and ventilated.

Attention to these and some of the other details mentioned in this lecture ought to enable engineers, and bridge builders to undertake, and to carry to a successful issue engineering operations upon even a greater scale than they have hitherto done, operations that would be quite consistent with the health, and with the safety of workpeople.

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1) Der Sauerstoff in der Prophylaxis und Therapie der Luftdruck-Erkrankungen, Berlin, 1904.

COMPRESSED air locomotives are built to run one-half to three miles without being recharged. This distance can be doubled if storage tanks are carried on the tender. The time required for recharging is about one and one-quarter minutes.

THOUGH the demand for pins the world over is enormous, the mills of the United States practically supply the entire demand. Formerly pins were expensive, but now they cost a mere trifle. In 1905 the 75,000,000 people in the United States used 60,000,000 gross of common pins, which is equal to 9,500,000 pins, or an average of about 126 pins for every man, woman and child in the country. This is the highest average reached anywhere in the use of pins. Ten years ago we used only about 72 pins each. The total number of pins manufactured in the United States during 1900, the census year, was 68,889,260 gross. There are 43 factories in all, with 2,353 employes. The business has grown rapidly during the last 20 years, for although there were 40 factories in 1880 they produced only half as much, employed only about half the capital and only 1,077 hands.

One of the causes of a serious loss in the transmission of compressed air is pumping the air of the engine room rather than air drawn from a cooler place. This loss amounts to from 2 to 10 per cent.

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Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

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HENRY C. SERGEANT

Henry Clark Sergeant of the Ingersoll-Sergeant Drill Company—now an integral part of the Ingersoll-Rand Company—died at his home, Westfield, N. J., Jan. 30th, seventy-two years old.

Mr. Sergeant was of world-wide repute as a facile, prolific and highly successful inventor, especially in the line of rock-drills, air-compressors and mining and excavating machinery in general, his active life having been coincident with the period of development of the modern and phenomenally efficient apparatus now so universally employed and with such industriously revolutionary results, he having been a leading and constantly active agent not only in the line of invention and improvement but also in the devising of the details and the means of precise and economical manufacture.

Mr. Sergeant was born at Rochester, N. Y., but his earlier years were spent in Ohio. He was of uncurbable activity, both physical and mental, from the beginning. He had only a common school education and was working in the machine shop at a very early age. His irrepressible inventive faculty made work for itself from the first. He quickly began to see the undeveloped possibilities of systematic manufacture by the aid of special machinery. His first practical application of his theories was to the making of the spokes, hubs and felloes of wagon wheels. He designed some special machines for this work and at the age of eighteen he accepted a contract for manufacturing wheel parts in quantity. In this he was so successful that in two years he was taken into partnership by a firm manufacturing wagon wheels.

The routine of the factory, however, could not hold him and after severing this first business connection the next six years of his life were spent in various pursuits, chiefly commercial, in which he met with varying success. He was a ready speaker, though not known as such in later years, and found favor as a lecturer. He had figured for a time also as a champion skater. He still found time and opportunity in the line of invention and the development of labor saving machinery. His first U. S. patent, issued when he was nineteen, was for a boiler feed. Succeeding patents suggest the range of applicability of his inventive faculty. In December, 1858, he patented a steam engine governor. This was in fact a governor for marine engines to prevent their racing to destruction when the wheels are out of water. This was soon after adopted by the U. S. Government and applied to the warships of the period. He had after that patents respectively for gas regulators, for steam pumps, four for steam boilers, five for brick machines, a fluting machine, six for water meters, all these before he had struck what must now be considered as his life work.

Three of the brick machine patents were issued in 1867, when he was a resident of Columbus, Ohio, but soon after that he started a machine shop of his own in New York, building a wide variety of machines and developing many crude ideas into practical working successes. In the early seventies hither came Simon Ingersoll with the drawings for the first Ingersoll rock drill, a then untried device. The possibili-

HENRY C. SERGEANT.

ties of and the large future for the rock drill particularly attracted Sergeant. None can say now how much he contributed to the development and success of the original Ingersoll drill, but at least one patent was issued to Ingersoll and Sergeant as joint inventors. The Ingersoll Drill Company was formed and introduced the drill in the rock excavating fields.

Although the drill was at first operated by steam its advantages when driven by compressed air and the absolute necessity for using air for mine and tunnel work turned Sergeant's attention to the improving of the design and details of the air compressors, which the Ingersoll Company began to market in connection with the drills and for other incidental uses which began to develop.

He was soon working with all his energies in both lines and constantly bringing both the drill and the compressor into higher offices. As the business grew the partnership of Sergeant and Cullingworth was formed with shops at 22nd Street and Second Avenue, New York.

The water meter patents spoken of, were issued during these early business years in New York, and in this line he was in touch with Jose F. de Navarro, two patents issuing to him as joint inventor with Sergeant.

Again turning from the task of manufacturing, Mr. Sergeant's interest was sold to the Ingersoll Drill Co., and he went to Colorado to put into practical operation some of his mining methods. He operated a silver mine for a time, but fortunately we may now say, it was not a success. Meanwhile he had developed another complete rock-drill with an entirely novel valve motion. Two patents on this drill are dated 1884. He brought his new drill East in 1886 and formed the Sergeant Drill Company, which began building the drill at Bridgeport, Conn. Two years later the new company joined hands with the Ingersoll interests and the Ingersoll-Sergeant Drill Company was formed with Mr. Sergeant as its first president. The new company's shops were at 9th Avenue and 27th Street, these shops having been occupied for a short time previously by the firm of Sergeant-Cullingworth, which then went out of existence, Mr. Sergeant's interest in this firm having terminated before he went to Colorado. Mr. Sergeant remained at the head of the company but a short time, he then disposing of the bulk of his interest. A considerable time was then spent in London and Paris. He returned to the rock-drill-business, this time as a director in the Ingersoll-Sergeant Company, with the purpose of devoting all his time to invention in the interest of the company. He labored constantly in developing and improving the company's products and in spending their application into new and wider fields, his most notable inventions being the Sergeant "Auxiliary" and "Arc" valve, "Tappet" rock-drills, the Sergeant Release Rotation for rock-drills and the Piston Inlet valve for air compressors, all of which are in general and successful use to-day. He was also the originator of many new ideas in stone channeling, coal undercutting and associated lines.

In the days of the Sergeant-Cullingworth Company, in response to the solicitations of the management of the Third Avenue Elevated Railroad Company, of which he was then a director, for a device which would protect them from the constant losses accruing from the repeated use of uncancelled tickets, he designed the ticket cancelling box now so familiar to the public which so mutilates the ticket as to make it impossible to defraud the company by using it again.

Mr. Sergeant's inventive faculty and his suggestive and stimulating ideas were devoted to the interests of the Ingersoll-Sergeant Company for all the remaining years of his active life, and the business grew and prospered continually. The works at Easton, Pa., were occupied in 1873, the great shops at Phillipsburg being a necessity a decade later. He spent much of his time in Easton until two years ago, when failing health compelled him to give up his former activities.

After the consolidation of the Ingersoll-Sergeant and Rand companies, he still retained his interests, although his health would not permit his active participation.

In his early days Mr. Sergeant was never content to tarry long under fixed conditions or in the same location, and up to 1893 he had made his home in twenty-six different cities and towns. In that year he located at Westfield, N. J., and at once took a deep interest in the growth of what was then but a small settlement. He built and owned at the time of his death the present home of the Westfield Club, the leading social organization in that section. He was a great sufferer from rheumatism in his latter years, but the immediate cause of his death was paralysis. He is survived by three daughters, a son and a brother. Mr. Sergeant was a man of all-embracing interests and of most extensive experience, a genial companion in the hours of leisure as he was an indefatigable worker when anything was to be done. He was absolutely without ostentation and there was no suggestion about him of his talents or his achievements. He had, however, an unbounded confidence in his abilities as all must have who accomplish much.

Mr. Sergeant is to be considered to have been a fortunate inventor, in that his inventions were so completely successful in the accomplishment of the purposes for which they were designed and have attained such a leading position in the large operations which accompany the advance of modern civilized life, although he realized from them no great fortune, as fortunes go now, and at best attained little more than a modest competence.

The world was most fortunate in the life work of such an inventor in the special line which engaged him. The importance of Mr. Sergeant's labors will be appreciated only when the results which he made possible are realized; and when will that be? Without the rock-drill, which he did more than any other man to make a success, such enterprises as the Chicago Drainage Canal, the Niagara power development, the New Croton Aqueduct, the New York Subway, the Panama Canal, the subaqueous tunnels now being built in and for Greater New York, would not have been commercially possible. Added to this list of achievements done, or now certain of accomplishment, directly due to Sergeant's genius must be named the gigantic railway system of America which could never have been built without the rock drill and the air-compressor, for tunneling, for heavy rock cuts, which give easy grades, etc. The mineral output of this and of all other countries in gold, silver, copper, iron, coal, building stones, etc., has been multiplied over and over by the rock-drill alone.

As an inventor he had probably no special predilection in the direction of the specialties in which success came to him, his real specialty being merely to accomplish the thing which it thus came in his way to do. His chief characteristic may be said to have been a certain mental alertness, a quickness to see the best way to do a thing or in ways already devised to see the little thing lacking, and to supply it, transforming a device of doubtful value often into a great success. This faculty he applied as he had opportunity to the inventions of his competitors, as he had an undoubted right to do, and as it was to the interest of mankind that he should do, and in which he was as far from being a plagiarist or a mere adapter as if a competitor had never existed. The pronounced and indisputable character of his inventions is attested by the fact that with more than fifty patents to his name so few of them have ever been subjects of litigation.

"SALES NIGHT"

"Sales Night" of the Technical Publicity Association was held at the rooms of the Aldine Association, 111 Fifth Avenue, New York, Thursday, January 31 The Association received the first report of its Circulation Committee, which has been requesting reports on circulation, etc., from the various technical magazines in which T. P. A. members are interested. As was expected, the stronger magazines have shown themselves eager to go on record with detailed statements.

The companies represented by members at the meeting were: Yale & Towne Mfg. Co., Johns-Manville Co., American Wood Working Machinery Co., F. R. Almond Mfg. Co., General Electric Co., Crocker-Wheeler Co., American Locomotive Co., Cameron Steam Pump Works., N. Y. Telephone Co., N. Y. Edison Co., B. F. Sturtevant Co., A. A. Griffing Iron Co., A. Allan & Son, Goulds Mfg. Co., Prentis Tool & Supply Co., J. G. Brill Co., and Lidgerwood Mfg. Co.

TRADE PUBLICATIONS

Struthers-Wells Company, Warren, Pa.—28-page catalog and price list of boilers for permanent and portable work, also 42-page catalog illustrating the full line of steam and gas engines, boilers, tanks, etc., manufactured by this company.

T. H. Proske, 1734 15th St., Denver, Colo.—Small booklet describing the Ajax Drill Sharpener, having a capacity of 1,200 drills in 24 hours. The booklet also contains a great deal of interesting data on the subject of drill bits.

Armour Institute of Technology, Chicago Ill.—Fourteenth Annual Year Book for 1906-1907, giving full information regarding the various engineering courses offered by the Institute.

St. Louis, Well Machine and Tool Company, St. Louis, Mo.—Circulars A to L, illustrating the full line of portable drilling machines and drilling tools manufactured by the company.

Joseph T. Ryerson & Son, Chicago, Ill.—Monthly stock list and journal giving full information regarding the material which they carry in stock for immediate delivery together with interesting articles covering engineering and business subjects.

Chicago Pneumatic Tool Co., Fisher Bldg., Chicago, Ill.—Catalog No. 21, 60 pages, 6x9, covering their line of electric drills, grinders, drilling stands, etc. This catalog is fully illustrated and the information regarding machines is placed in tabular form.

Arthur Koppel Co., 68 Broad street, New York—Catalog No. 111, 48 pages, 8x10, covering their complete line of Industrial Railway Equipment for manufacturing plants, quarries, contractors' work, power plants, etc.

Automatic Oil Cup Company, 155 Huron St., Milwaukee, Wis.—12 page booklet, 6x9, devoted to the subject of lubrication and explaining the uses of the Bangs Automatic Oil Cup to various classes of machinery.

Ingersoll-Rand Company, 11 Broadway, New York—Catalog No. 46, 84 pages, 6x9, devoted to Rand Rock Drills, their construction and operation. This catalog gives full information regarding the Rand Little Giant Drill and various fittings, such as tripods, quarry bars, drill steels, air and steam hose. The catalog also covers thoroughly the design and adaptability of the Rand Slugger Rock Drill.

Catalog No. H-36 describing a single line of air compressors known as Type H. These compressors are duplex, steam-driven, automatic machines, mounted upon a single base and entirely self-contained.

Booklet, 12 pages, 6x9, entitled "Some Economical Applications of Compressed Air in Cotton Industries." This interesting pamphlet calls attention to the safety, especially as to fire, of compressed air as a motive power in cotton factories, and points out the numerous ways in which it may be used to advantage.

Western Electric Company, New York.—Souvenir book, 24 pages, 10¾x7½, describing and illustrating their Hawthorne Works for the manufacture of power apparatus.

The Railroad Supply Company, Chicago Ill.—Small booklet, 140 pages, entitled "A Pocket Companion for Trackmen," containing a vast amount of useful data on track equipment and construction.

C. Drucklieb, 132 Reade St., New York.—Small booklet devoted to the subject of the application of the Injector Sand Blast Apparatus to railroad work, especially for cleaning steel bridges and other structural steel work. This booklet contains a great deal of valuable information regarding the application and operation of the Sand Blast.

Blaisdell Machinery Company, Bradford, Pa.—Bulletin No. 12, 28 pages, 6x9, devoted to a description of Blaisdell Self-oiling Air Compressors. This bulletin describes the new Blaisdell Air Compressor, mention of which was made in the February issue of COMPRESSED AIR.

Catalog, 46 pages, 6x9, devoted to Classes SA and DSA Air Compressors as well as pneumatic tools, plug drills, surfacing machines, unloaders, gasoline engines, etc.

Hanna Engineering Works, 820 Elston Ave., Chicago, Ill.—12-page folder illustrating and describing Hanna Riveters for structural steel work. This riveter is claimed to be the only pneumatic machine which will exert a positive uniform maximum pressure on the rivet throughout the last half of piston travel. Furthermore, it requires no adjustment for ordinary variations in length of rivets or thickness of plates.

Allis-Chalmers Company, Chicago, Ill.—Catalog No. 17, 6th Edition, 12 pages, 6x9, describing their line of mining and quarry cars, skips and buckets, with a detailed description of their Anaconda Car Axles. This catalog also contains information on ore buckets, water buckets, automatic dumping cars and scoop ore cars.

Marceline Steel Company, 13-21 Park Row, New York.—Small booklet, 3½x6, 12 pages, describing a new high-speed steel, made in three grades, i. e. Marceline "Three Star," Marceline "Two Star" and Marceline "One Star." It is claimed by actual tests in England and on this Continent that this steel has proven 100 per cent. better, both in speed and lasting qualities, than any other steel. Furthermore it has the peculiarity that when re-ground it works much better than when new. One of its chief characteristics is that when hardened it remains tough, and does not have any tendency to crack and chip when made into milling cutters and other tools of like nature. This steel requires no treatment, and by its use any toolmaker can produce high-grade tools without special instructions.

* * *

INDUSTRIAL.

CHICAGO PNEUMATIC TOOL CO.

In his report to the stockholders of the Chicago Pneumatic Tool Co. for the year ended December 31, 1906, President J. W. Duntley makes reference to the statement in the previous annual report of the policy of the management in "developing, broadening and extending" the business of the company, and adds:

"The largely increased sales and profits realized, amounting to 11.237 per cent. available for dividends, would indicate that substantial results have been obtained. Of the amount earned during the year, amounting to $686,468.61, available for dividends, your directors have appropriated 4 per cent. for dividends declared, and the remainder, amounting to $442,117.29, has been added to surplus account."

HAS GREATER MARKET.

The company has acquired the Consolidated Pneumatic Tool Co., Ltd., of London, and has organized the Internatinale Pressluft & Elektrigitaets-Gesellschaft, Berlin, and has bought the Canadian Pneumatic Tool Co., Ltd., Montreal. All of these organizations, says the report, show during the year increased volume of business and substantial gains in assets with the result that the company has benefited in additional facilities for marketing its output, with resulting increased profits. In connection with the acquirement of the business of the Philadelphia Pneumatic Tool Co. of Philadelphia, and the organization and extension of the foreign companies, it was thought desirable to borrow temporarily $195,000, which is included in the item "Bills payable," amounting to $247,499.94. The amount so borrowed has been more than offset, the report asserts, by the additional assets acquired.

Additions to plants have been made during the year and development work completed has exceeded that of the previous year.

Mention is made of the fact that of the authorized issue of $2,500,000 bonds, $200,000 are still in the treasury, and $293,000 have been retired for sinking fund purposes, leaving outstanding $2,007,000. The excess current assets on December 31, 1906, $1,542,075.99, show an increase of more than $883,000.00 since the company was organized five years ago.

THE James Leffel Co., Springfield, Ohio, have issued a very handsome and complete new 52-page catalogue, illustrating and describing their line of steam engines and boilers. The details of construction are plainly shown and fully explained, and the catalogue is one that should be in the hands of any prospective purchaser of work in the steam power line. A copy will be furnished free to prospective buyers, stating their wants, and addressing the company as above. In writing for this catalogue request Catalogue "O."

WEIGHING COMMON AIR

The weight of air has often been tested by compressing it in receptacles by the air pump. That it really has weight when so compressed is shown by the fact that the weight of the vessel is increased slightly by filling them with compressed air and that such vessels become specifically "lighter" as soon as the air contained in them is exhausted. Many elaborate experiments on the weight of air have proved that the cubic foot weighs 536 grains, or something less than one and a quarter ounces. The above experiment on the weight of air is supposed to be made at the surface of the earth with the temperature at 50 degrees F. Heated air or air at high elevations is much lighter.

The Independent Pneumatic Tool Co. of Chicago announce that the sales of their "THOR" Pneumatic Tools and appliances during 1906, showed an increase of 50 per cent. over 1905, and they are now several months behind in their orders.

On account of the rapidly increasing demand for their products, their present manufacturing facilities are inadequate to meet requirements, and they have accordingly, purchased a large four-story brick building adjoining their plant at Aurora, Illinois, which will give approximately 100,000 square feet of additional floor space, and they intend to install therein, at the earliest possible date, about $65,000 worth of additional machinery of the latest improved type. By the acquisition of the building mentioned, and additional machinery, they expect to double their output this year. Mr. A. B. Holmes, who is at present Secretary of the Company, has also been elected Treasurer, effective January 16th. The Board of Directors at a recent meeting declared a regular quarterly dividend of 3 per cent.

IN STOCK FOR IMMEDIATE SHIPMENT.

Messrs. Joseph T. Ryerson & Son, Chicago, announce that they have the following machinery in stock for immediate shipment:

One 6 inch throat punch, capacity ½ inch hole in ½ inch plate.

Two 12 inch throat punches, capacity ¾ inch hole in ¾ inch plate.

Two 36 inch throat punches, capacity ¾ inch hole in ¾ inch plate.

Three 36 inch throat punches, capacity 1 inch hole in 1 inch plate.

Three Lennox Rotary Splitting shears for ½ inch material, 30 inch throat.

One Lennox Rotary Splitting shears for ¼ inch material, 42 inch throat.

Three Lennox Rotary Splitting shears for ¾ inch material, 8 feet between housings.

One combination punch and shear, 15 inch gap, capacity ⅝ inch hole in ⅜ inch plate and as a shear 1¼ inch round bars.

One hand power beam shear, capacity 15 inch, 60 lb. I beams.

One Alligator Riveter, capacity 1 inch rivets.

One set of bending rolls, capacity ⅜ inch material, 6 feet 2 inches between housings.

One 600-lb. Bell Standard Guide Steam Hammer.

One 10x8 Belt driven Air Compressor.

One 10x10x10 Steam-driven Air Compressor.

Besides the above mentioned, they carry at all times rotary bevel shears, flue welding machines, flanging clamps, power hammers, and a full line of miscellaneous hand and power tools.

CONVENTION OF THE ASBESTOS MEN.

Annual Meeting of the Sales-Staff of the H. W. Johns-Manville Co.

During the past month the various branch managers and department managers of the H. W. Johns-Manville Co., held their Annual Convention at the headquarters of the company, 100 William St., New York. This company has a world-wide reputation as being the largest manufacturer of asbestos, magnesia and electrical products in the United States, if not in the world, having factories at Brooklyn, Milwaukee, West Milwaukee and Hartford Conn., and branch offices and warerooms in the following cities: Milwaukee, Chicago, Boston, Philadelphia, St Louis, Pittsburg, Cleveland, San Francisco Los Angeles, Seattle, Kansas City, Minneapolis, New Orleans, Dallas and Buffalo. Representatives from the various branches and factories were present, and the meeting was not only profitable but interesting to everyone present.

As a fitting finale, the Convention wound up with a banquet at the Waldorf Astoria.

A GUIDE TO NEW YORK

"A Day in New York" is the title of an interesting and helpful little booklet issued by the Joseph Dixon Crucible Company for visitors to the metropolis. General information as to the topography of the city, its main thoroughfares, points of interest, churches, etc., is given.

A unique feature, and one which will appeal to the visitor whose time for sight-seeing is limited, consists in plans for one-hour, two-hour, half-day, evening and whole-day tours of the city. The routes are carefully planned and remarkably comprehensive. Hints for saving time and trouble, rates for cab and coach hire and a list of subway stations complete the book.

The prospective traveler to New York, be he teacher or business man, should not fail to write for a copy to the Joseph Dixon Crucible Company, Jersey City, N. J

CHIPPINGS.

SIZE AN IMPORTANT FACTOR IN PNEUMATIC TIRE DESIGN

Compressed air in motion generates heat. The faster the speed the greater the heat; the greater the heat, the greater the strain on the tire; the larger the tire, the less the increase of heat and strain. So it will be understood that the faster the speeed the greater the load per wheel and tire. If there is not sufficient volume of compressed fluid air within a tire to absorb the whole of the shock or vibration the surplus shock is received by the cover of hte tire, which dashes it to the car and engine, causing damage to tire and to sar in a manner similar to the way in which a pool of water receives a solid bayd thrown into it. If the pool be small, the reception of the shock causes a violent dashing of water against the banks; if the pool be large enough the disturbance is imperceptible. As the compressed fluid air within a tire must be reached through the solid cover, it stands to reason that the cover should be as yielding, flexible and sensitive as is consistent with road wear, to interfere as little as possible with quick communication of shock to the fluid cushion.

At several mines in Europe small compressors, electrically driven, have been installed underground, each compressor serving a group of drills. The compressor, motor and receiver are sometimes arranged on a truck, which can be moved to follow the development of the mine. The electrical cable is wound on a drum, enabling an easy adjustment of the length. The efficiency of these installations has been found very good. By this method the theoretical advantage of the electric drill is approached, while the practical advantage of the air drill is retained.—*Engineering and Mining Journal.*

Well drillers desiring to calculate the rate of flow of an artesian well lower a bottle of aniline fluid to a depth of, say, 500 feet, and then electrically explode a cap to burst the bottle. The time required for the fluid to appear at the surface gives an accurate gauge as to the velocity of flow. It is claimed that this method gives results as accurate as a weir. The diameter of the pipe being known, the rate of flow readily follows.

When a shaft is sunk by the pneumatic process the lining is generally called a caisson, which in form may be likened to (as far as the water shell is concerned) an inverted tumbler, charged with air above the normal pressure, the edge of the glass representing the cutting edge of the caisson and the top the base upon which the winding apparatus, locks, etc., are placed. The weight of the caisson, including the superstructure, forces the cutting edge into the strata, and as the strata inside are removed the caisson sinks and forms the wall of the new shaft. As a general rule, little or no additional weight other than that of the winding apparatus and locks is required at the early stages of the sinking, but, as the friction caused by the strata pressing against the outer wall of the caisson increases, additional weight is required to be added to the superstructure. The weight is very considerable, and may run into hundreds of tons. Where the strata consists of soft material, and the digging inside the caisson is evenly done, the keeping of the structure in a vertical position is not, as a rule, a very difficult matter; but in the event of the caisson deviating from the plumb line, as it may do through subterranean influences, or through the occurrence of boulders in the strata, the additional weight must be so distributed as to check or remedy the defect during the continuance of the sinking. The compressed air inside the caisson retards the lowering of the structure, and as a rule the air pressure is reduced in the absence of the workers so as to allow the caisson to sink.—*Mining Reporter.*

One distinct advantage resulting from the use of machines in coal mining is due to the increased safety afforded the miner. This is especially true in a high seam (7 ft.), where the miner often attempts to get down the coal by using a heavy charge and shooting on the solid. Where such a hole is improperly loaded or wrongly placed, a blow-out or windy shot results, sometimes causing gas or dust explosions. If machine undercutting is practiced, the explosion has two free faces on which to exert its force instead of one, so the danger of missed shots is greatly lessened. It is a serious question whether it would not be best for all States to prohibit shooting coal from the solid.—*Engineering and Mining Journal.*

U. S. PATENTS

ESPECIALLY PREPARED FOR COMPRESSED AIR

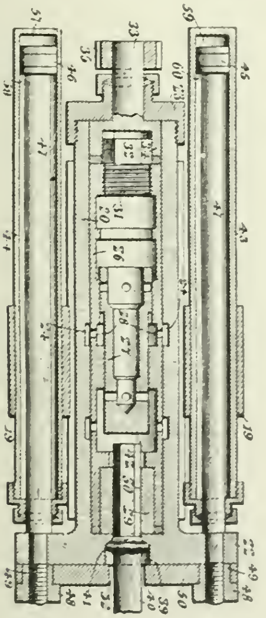
Full specifications regarding any of these patents may be obtained by sending five cents to the Commissioner of Patents, Washington, D. C. (Stamps will not be accepted.)

843,598. STEAM AND AIR VALVE OPERATOR. David H. Greeson, Bowie, Tex., assignor to Greeson, Burnett & Co., Bowie, Tex. Filed Apr. 20, 1906. Serial No. 312,850.

843,701. AUTOMATIC AIR-BRAKE COUPLING FOR RAILWAY-CARS. Frank H. Rutherford, Chicago, Ill. Filed June 13, 1906. Serial No. 321,547.

843,702. AUTOMATIC AIR-BRAKE COUPLING FOR RAILWAY-CARS. Frank H. Rutherford, Chicago, Ill. Filed Sept. 17, 1906. Serial No. 334,904.

843,718. ROCK-DRILL-FEEDING MECHANISM. Thomas Turner, Ottumwa, Iowa. Filed May 9, 1906. Serial No. 315,978.



Claim.—In mechanism of the class described, the combination, with a motor, of a plurality of fluid-actuated feeding devices for moving the motor, and means for admitting motive fluid to one or more of the feeding devices to vary the pressure thereof upon the motor.

843,758. AIR-BRAKE SYSTEM. George Macloskie, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed June 22, 1906. Serial No. 322,845.

843,806. PNEUMATIC CONVEYER. Clarence L. Groves, Hartford City, Ind., assignor, by direct and mesne assignments, of one-half to George R. Meyers and one-half to T. J. D. Larmoyeux, Hartford City, Ind. Filed Apr. 27, 1906. Serial No. 314,[illegible]28.

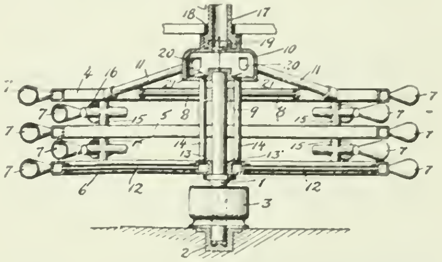
Claim—1. A pneumatic conveyer having a fan, a fan-chamber, a tangential feed-pipe, an air-inlet to the fan-chamber adjacent to the point where the tangential feed-pipe connects with the chamber, a door in the lower portion of the fan-chamber, and a tangential outlet-pipe.

843,909. ATMOSPHERE REGULATING SYSTEM. Frank M. Peters and Henry H. Hungerford, Chicago, Ill., said Hungerford assignor to said Peters. Filed June 8, 1903. Serial No. 160,620.

843,926 PROTECTING OBJECTS FROM WAVE ACTION. Philip Brasher, New York, N. Y. Filed Nov. 22, 1906. Serial No. 344,553.

Claim—1. The method of protecting objects from the action of water-waves which consists in discharging a compressed elastic fluid below the surface of the water between the object and the approaching waves and at a substantial distance from the object.

844,173. AIR-COMPRESSOR. Alexander McCarthy, New York, N. Y. Filed Dec. 2, 1905. Serial No. 289,943.



Claim.—1. In an air-compressor, a plurality of tubular rings, means for supporting and rotating said rings, and a plurality of air-receiving buckets carried by said rings.

844,270. AIR-BRAKE ATTACHMENT. George Emery, Argenta, Ark. Filed Apr. 7, 1906. Serial No. 310,444.

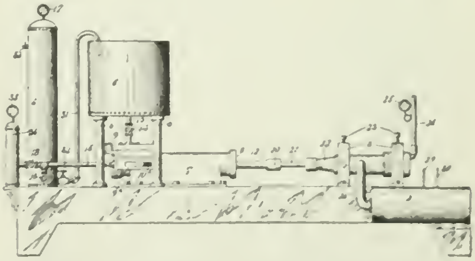
838,520. AIR-BRAKE. Benjamin Canell, West Springfield, Mass. Filed July 10, 1906. Serial No. 325,438.

838,692. AUTOMATIC FUEL-VALVE. Alfred W. Dater, Stamford, Conn. Filed Dec. 20, 1905. Serial No. 292,584.

838,887. PUMP. Henry Nagel and John E. Nagel, Brunswick, Neb. Filed May 13, 1905. Serial No. 260,276.

839,031 PNEUMATIC TOOL. Harold A. R. Prindle and John U. Adolph, Philadelphia, Pa. Filed Oct. 10, 1904. Serial No. 227,896.

839,111. APPARATUS FOR TESTING PNEUMATIC TOOLS. Robert A. Chambers, New Glasgow, Nova Scotia, Canada. Filed July 23, 1906. Serial No. 327,294.



Claim.—1. In a device of the class described, a cylinder, a piston therefor, adjustable means for introducing a column of water into said cylinder, a compressor-tank, means connecting said compressor-tank and cylinder, a reciprocating tool attached to said piston, and means for registering the impact of the piston against a column of water within the cylinder.

839,115. HUMIDIFYING DEVICE. Charles M. Colvin, Wilmette, Ill., assignor of one-half to Sackett H. Verrall, Chicago, Ill. Filed May 17, 1906. Serial No. 317,297.

839,168. MACHINE FOR FORMING SHEET-GLASS. John L. Maloney, Bellaire Ohio, assignor of one-fifth to Thomas Moran, Bellaire, Ohio. Filed July 12, 1906. Serial No. 325,909.

839,186. AIR-BRAKE SYSTEM. Jay Noble, St. Louis, Mo. Filed July 10, 1905. Serial No. 268,997.

839,254. AUTOMATIC INKSTAND. Frank M. Ashley, New York, N. Y., assignor of one-half to George D. Mumford and Henry Willard Bean and one-half to Albert T. Scharps, New York, N. Y. Filed Apr. 9, 1898. Serial No. 677,004.

839,255. CIRCUIT-OPENING DEVICE FOR ELECTRIC HEATERS. James I. Ayer, Cambridge, Mass., assignor to Simplex Electric Heating Company, Boston, Mass., a Corporation of Massachusetts. Filed May 5, 1905. Serial No. 258,922.

839,312. PRESSURE-BLOWER. Christian Neumann, St. Louis, Mo. Filed Jan. 28, 1905. Serial No. 243,053.

839,327. SAFETY ELEVATOR AIR-BRAKE. Fred E. Small and Theodore M. Latsch, Los Angeles, Cal. Filed Apr. 24, 1906. Serial No. 313,371.

839,366. AIR-BRAKE SYSTEM. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed June 5, 1905. Serial No. 263,703.

839,586. ROCK-DRILL. Henry Hellman and Lewis C. Bayles, Johannesburg, Transvaal. Filed May 31, 1904. Serial No. 210,519.

839,598. SAFETY DEVICE FOR AIR-BRAKES. Joseph Judge, Pittston, Pa. Filed Aug. 28, 1906. Serial No. 332,335.

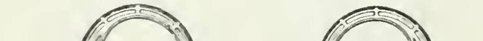
839,626. DEVICE FOR INFLATING THE PNEUMATIC TIRES OF VEHICLES. Carl Nielsen, Copenhagen, Denmark. Filed Dec. 14, 1905. Serial No. 291,755.

839,727. HANDLE FOR PNEUMATIC HAMMERS. Charles T. Carnahan, Denver, Colo. Filed July 31, 1906. Serial No. 328,583.

839,769. AIR-BRAKE MECHANISM. Elmore C. Jordan and Charles B. Brown, Los Angeles, Cal. Filed Feb. 20, 1906. Serial No. 302,114.

840,464. PNEUMATIC-TUBE SYSTEM. Birney C. Batcheller, Philadelphia, Pa., assignor to The Pearsall Pneumatic Tube and Power Company, New York, N. Y., a Corporation of New York. Filed May 1, 1905. Serial No. 258,288.

840,465. PNEUMATIC-TUBE SYSTEM. Birney C. Batcheller, Philadelphia, Pa., assignor to The Pearsall Pneumatic Tube and Power Company, New York, N. Y., a Corporation of New York. Filed May 1, 1905. Serial No. 258,289.



Claim.—1. In a pneumatic-tube system, the combination of a tube, a gate or valve for closing its end, a connected air-supply pipe, a valve for controllnig the admission of air from said pipe to the tube, means for opening the air-valve and closing the tube-gate, a manually-operated device for operating said means, an automatic latch for holding said valve in open and said gate in closed position, and a time-escapement mechanism acting to release said latch and positively and directly set in operation by the manually-operated device for actuating the valve and gate as aforesaid.

840,499. SPEED-GOVERNOR. John Knowlson, Troy, N. Y. Filed May 7, 1906. Serial No. 315,478.

840,530. AIR-FILTER. Ira F. Wallace, Minneapolis, Minn., and William L. Kellogg, Sioux City, Iowa. Filed Oct. 11, 1901. Serial No. 78,288.

840,605. TRANSMISSION-GEAR. Charles H. Brooks, Detroit, Mich., assignor to The Brooks Motor Company, Detroit, Mich., a Corporation of Michigan. Filed Mar. 30, 1906. Serial No. 308,858.

840,724. PNEUMATIC CLEANER AND SEPARATOR Bert E. Sweet, Lodi, Cal. Filed Dec. 28, 1905. Serial No. 293,646.

840,816. ROCK-DRILL. Thomas E. Adams, Cleveland, Ohio, assignor to The Adams Drill Company, Cleveland, Ohio, a Corporation of Ohio. Filed Oct. 24, 1901. Serial No. 79,832

840,880. PNEUMATIC-DESPATCH APPARATUS. Fred R. Taisey, Indianapolis, Ind., assignor to The Lamson Consolidated Store Service Company, Boston, Mass., a Corporation of New Jersey. Filed May 24, 1906. Serial No. 318,473.

841,001. SELF-CONTAINED ROCK-DRILL. Otho C. Duryea and Morris C. White, Los Angeles, Cal., assignors to National Gas Drill Company, a Corporation of California. Filed Apr. 28, 1903. Serial No. 154,678.

841,069. PNEUMATIC DRILL. Harry P. Taylor, Salt Lake City, Utah. Filed Apr. 28, 1905. Renewed July 14,1906. Serial No. 326,277.

841,636. AUTOMATIC AIR-BRAKE FOR CARS. William J. Dankel, Pittsburg, Kan. Filed Mar. 24, 1906. Serial No. 307,812.

841,139. ROCK-DRILL. Arthur H. Gibson, Easton, Pa., assignor to The Ingersoll-Sergeant Drill Company, New York, N. Y., a Corporation of West Vriginia. Filed July 28, 1905. Serial No. 271,602.

841,162. LUBRICATOR FOR PNEUMATIC ENGINES. Wilfred Lewis, Philadelphia, Pa., assignor to Tabor Manufacturing Company, Philadelphia Pa., a Corporation of New Jersey, Filed Sept. 20, 1904 Serial No. 225,279.

841,231. AIR-BRAKE SYSTEM. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed May 25, 1906. Serial No. 318,883.

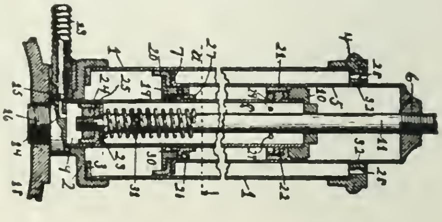
841,469. PRESSURE - CONTROLLING VALVE FOR AIR-BRAKE SYSTEMS. Walter V. Turner, Wilmerding, Pa., assignor, by direct and mesne assignments, to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed July 6, 1903. Renewed Mar. 31, 1906. Serial No. 309,052.

841,751. AIR-BRAKE. Henry H. Westinghouse, New York, N. Y., assignor to The Westinghouse Air-Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Oct. 6. 1904. Serial No. 227,374.

842,003. PRESSURE-ACTUATED VALVE FOR ENGINES. Thomas Officer and Henry H. Mercer., Claremont, N. H., assignors to Sullivan Machinery Company, Claremont, N. H., a Corporation of Maine. Filed Oct. 30, 1905. Serial No. 284,991.

842,136. METHOD OF TESTING PNEUMATIC TOOLS. Robert A. Chambers, New Glasgow, Novia Scotia, Canada. Filed July 23, 1906. Serial No. 327,293.

842,142. PNEUMATIC PUMP. Jacob Funck, Rochester, N. Y., assignor to Judd & Leland Manufacturing Company, Clifton Springs, N. Y. Filed Oct. 3, 1906. Serial No. 337,297.



COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

APRIL, 1907.

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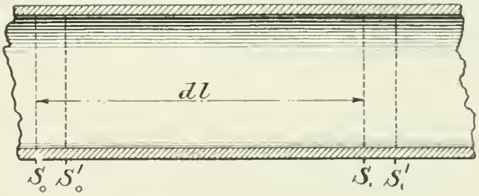
THE FLOW OF AIR IN LONG TUBES WITH SPECIAL REFERENCE TO PNEUMATIC DISPATCH.

By B. C. Batcheller

PART I.

If a difference of pressure exists in different parts of a tube, a fluid filling the tube will flow from the place of higher pressure towards that of lower pressure. If the fluid be elastic—air, for example—as it moves it will expand according to well-known laws. The expansion indicates that work is being done. This work is expended in overcoming the resistance to flow, due to viscosity of the fluid and friction against the walls of the tube, resulting in eddy currents which, as they subside, impart heat to the gas, making the expansion nearly isothermal. The temperature of the air is determined by, and is nearly the same as that of the tube and its environment; if the air is at a different temperature when it enters the tube it becomes nearly the same after flowing a short distance, giving up or receiving heat by conduction, which transfer is accelerated by the rapid motion of the air particles among themselves. This has been demonstrated by the observations of M. Stockalper at St. Gothard's tunnel, and by observations on the postal tubes in Philadelphia. M. Stockalper observed that the temperature of the air flowing in a pipe 6,000 meters long was at every point about 3 degrees C. below that of the air surrounding the pipe.

FIG. 1.



William Cawthorne Unwin, formerly professor of engineering at the Guilds Central Technical College, London, was the first to construct a rational formula expressing the law of the flow of gases in long tubes. He assumed that the well-known formula for the flow of water, which has been tested by many careful experiments, is equally applicable to the flow of gases when modified so that the density and expansion of the elastic fluid as it flows is taken into consideration. Others have suggested using the formula for flow of water with a coefficient suited to the density of air but they have neglected to consider the constant change of density. Prof. Unwin's formula is derived by equating the work of expansion to the work of friction and the change of kinetic energy.

Derivation of the Fundamental Equation.

Figure 1 represents a short section of tube through which a constant current of air is flowing. The length of the tube between the transverse sections S_0 and S_1 is dl, the diameter d and the area of cross section A. Let P and u be the pressure and velocity at S_0, $P + dP$ and $u + du$ the same quantities as S_1. If in a short time, dt, the mass S_0S_1 moves to the position $S_0^1S_1^1$ then the distance $S_0S_0^1 = udt$ and $S_1S_1^1 = (u + du)dt$

The work of expansion of A u d t cubic feet of air to A $(u - du)$ dt cubic feet, at a pressure initially P, is

(1)

$$A\ P\ du\ dt$$

Let T = the absolute temperature.

G = the density or weight of air in pounds per cubic foot.

V = the volume of air in cubic feet per pound.

W = the weight of air in pounds flowing per second.

By the combined laws of Mariotte and Gay Lussac.

(2)

$$\frac{PV}{T} = R \text{ constant.}$$

Assuming the tube to have a uniform section, since the rate of flow is constant, the same weight of air flows past every transverse section per second therefore:

$$W = AGu \text{ constant,}$$

Or

(3)

$$W = \frac{Au}{V}$$

Combining this with (2)

(4)

$$u = \frac{WRT}{AP}$$

$$du = -\frac{WRT}{AP^2}\,dP$$

substituting in (1), the work of expansion is

(5)

$$-\frac{WRT}{P}\,dP\,dt$$

By analogy with the flow of liquids the head lost in friction measured in feet of fluid is

$$f\ \frac{u^2}{2g}\ \frac{dl}{m}$$

$$\text{Let} \qquad H = \frac{u^2}{2g}$$

then the loss of head is

$$f\ H\ \frac{dl}{m}$$

Since Wdt is the weight of air flowing through the space in the time dt, the work expended in friction is

(6)

$$f\ \frac{H}{m}\ W\,dl\,dt$$

The change of kinetic energy in the time dt is the difference of the kinetic energy of $S_1S_1^1$ and $S_0S_0^1$, that is

(7)

$$\frac{W}{2g}\,dt\left\{(u + du)^2 - u^2\right\}$$

$$= \frac{W}{g}\,u\,du\,dt$$

$$= W\,dH\,dt$$

The work done by gravity is zero if the tube is horizontal and this condition can be assumed usually without much error.

The work of the pressures on the sections S_0S_1 is

$$PA\,udt - (P + dP)\ A\ (u + du)\ dt$$

But since the temperature is constant

$$Pu = \text{constant}$$

$Pdu + udP = 0$, and the work of pressure is zero.

Placing the work of expansion equal to the work of friction and change of kinetic energy

(8)

$$-\frac{WRT}{P}\,dP\,dt = f\ \frac{H}{m}\ W\,dl\,dt + W\,dH\,dt$$

$$-\frac{RT}{P}\,dP = f\ \frac{H}{m}\,dl + dH$$

(9)

$$-\frac{RT}{HP}\,dP = f\ \frac{dl}{m} + \frac{dH}{H}$$

$$u = \frac{WRT}{AP}$$

$$H = \frac{u^2}{2g} = \frac{W^2R^2T^2}{A^2P^2 2g}$$

Substituting this value of H in (9)

(10)

$$-\frac{2g\,A^2\,P}{W^2\,R\,T}\,dP = f\ \frac{dl}{m} + \frac{dH}{H}$$

Integrating

$$-\frac{g\,A^2\,P^2}{W^2\,R\,T} = f\,\frac{1}{m} + \log H + \text{Constant}$$

Substituting the limits:

$$\begin{array}{lll} P = P_1 & l = o & H = H_1 \\ P = P_2 & l = L & H = H_2 \end{array}$$

$$-\frac{g\,A^2}{W^2RT}\left(P^2_2 - P^2_1\right) = f\,\frac{L}{m} + \log\frac{H_2}{H_1}$$

Remembering that P_1 is greater than P_2 and substituting for W and H

$$W^2 = \frac{A^2\,P^2_1\,u^2_1}{R^2\,T^2}$$

$$\frac{gRT}{P_1^2\,u^2_1}\left(P^2_1 = P^2_2\right) = f\,\frac{L}{m} + \log\frac{P_1}{P_2}$$

Solving for u_1

Let p_1 and p_2 be pressures in pounds per square inch, $R = 53.15$ and $r =$ the temperature of the air in degrees Fahrenheit, then

(13)

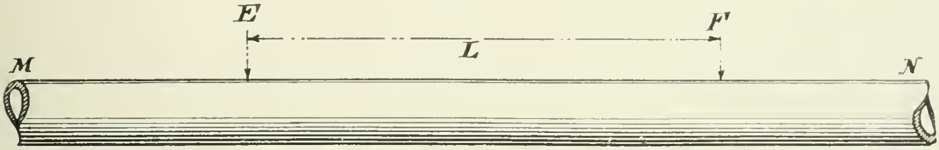
$$u = \sqrt{427.86\,\frac{(461 + r)\,d}{f\,L}\;\frac{p_1^2 - p_2^2}{p^2_1}}$$

Let MN, Fig. 2, represent a long tube of diameter d, in which a steady current of air is flowing from M toward N. Let the air pressure be measured with a pressure-gauge at two points E and F distant L feet apart. If the absolute pressure at E be p_1 and at F p_2, then the velocity of the air at E may be found by substituting these values in the above formula (13).

Pressure at Any Distance from the Origin

If the initial velocity and pressure, u_1 and p_1 are known, then the pressure p at any distance L from the origin can be computed thus:

FIG. 2.



(11)

$$u_1 = \sqrt{\frac{g\,R\,T\left(P^2_1 - \dfrac{P^2_1}{P^2_2}\right)}{P_1^2\left(f\,\dfrac{L}{m} + \text{Log}\,\dfrac{P_1}{P_2}\right)}}$$

When L is great $\log\dfrac{P_1}{P_2}$ is so small compared with $f\,\dfrac{L}{m}$ that it may be neglected; then

(12)

$$u_1 = \sqrt{\frac{g\,R\,T\,m\,(P_1^2 - P^2_2)}{f\,L\quad P_1^2}}$$

This is the fundamental equation for the flow of air in a long tube.

For tubes of circular section and diameter d, expressed in feet

$$m = \frac{d}{4}$$

(14)

$$p_x = p_1\sqrt{1 - \frac{f\,u^2_1\,L_x}{427.86\,(461 + t)\,d}}$$

Time of Transit.

Putting t for the time of transit of a particle of air from E to F, Fig. 2,

$$t = \int_0^L \frac{d\,l}{u}$$

From (10) neglecting $\dfrac{d\,H}{H}$

$$f\,\frac{d\,l}{m} = -\frac{2g\,A^2\,P}{W^2\,R\,T}\,d\,P$$

$$d\,l = -\frac{2g\,A^2\,P}{f\,W^2\,R\,T}\,d\,P$$

From (4) $\quad u = \dfrac{W\,R\,T}{A\,P}$

Therefore:

$$t = \int_{P_1}^{P_2} -\frac{2gm\ A^3\ P^2}{f\ W^3\ R^2\ T^2}\,d\,P$$

Integrating between the limits of P_1 and P_2.

$$t = \frac{2g\ m\ A^3}{3\ f\ W^3\ R^2\ T^2}\left(P_1^3 - P_2^3\right)$$

From (4) $$W = \frac{A\ P_1\ u_1}{R\ T}$$

Substituting

$$t = \frac{2gm\ R\ T}{3\ f\ u_1^3}\ \frac{P_1^3 - P_2^3}{P_1^3}$$

Substituting for u_1 the value given in (12)

(15)

$$t = \frac{2}{3}\ \frac{f^{1/2}\ L^{3/2}}{\left(g\ m\ R\ T\right)^{1/2}}\ \frac{P_1^3 - P_2^3}{\left(P_1^2 - P_2^2\right)^{3/2}}$$

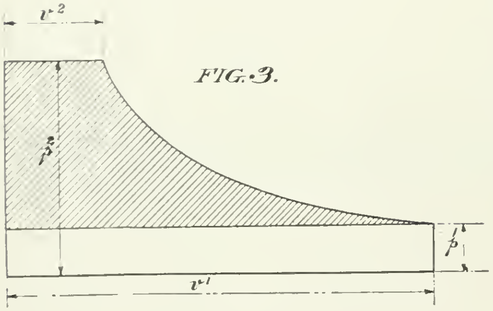


FIG. 3.

For circular tubes of diameter d, pressures p_1 and p_2 in pounds per square inch and temperature r in degrees Fahrenheit

(16)

$$t = 0.03223\sqrt{\frac{f\ L^3\ (p_1^3 - p_2^3)^2}{d\ (461 + r\ )\ p_1^2 - p_2^2)^3}}$$

Which gives the time of transit in terms of the initial and terminal pressures, temperature and dimensions of the tube.

Mean Velocity.

Having computed the time of transit, the mean velocity can be determined by dividing the length of tube L, by the time t

(17)

$$u_{mean} = \frac{L}{t}$$

or by substituting the value of t as given in (16) u_m can be computed directly from the pressures and dimensions of the tube, thus:

(18)

$$u_m = 31.027\sqrt{\frac{d\ (461 + r)\ (p_1^2 - p_2^2)^3}{f\ L\ \ (p_1^3 - p_2^3)^2}}$$

It is interesting to note what the limiting velocity will be as the terminal pressure p_2 approaches zero. According to (18) when $p_2 = 0$

$$u^1_m = 31.027\sqrt{\frac{d\ (\ 461\ +\ r\ )}{f\ L}}$$

which is independent of the initial pressure All that need be said is that this is an application of the formula beyond the realm of experiment, and is only interesting as a speculation.

Velocity at Any Distance from the Origin.

Having obtained the initial velocity of the air in the tube, the velocity at other points can be computed. For isothermal expansion and a constant cross section of the tube

$$u_2\,p_2 = u_1\,p_1$$

when u_2 and p_2 are the velocity and pressure at any desired distance from the origin and $u_1\,p_1$ the initial velocity and pressure.

(19)

Therefore: $$u_2 = u_1\,\frac{p_1}{p_2}$$

or by substituting (14)

(20)

$$u_2 = \sqrt{\frac{427.86\ (461\ +\ r)\ d\ u_1^2}{427.86\ (461\ +\ r)\ d - f\ u_1\ \ L}}$$

Weight of Air Flowing Per Second.

From (4) the weight of air flowing per second is

$$W = \frac{APu}{RT}$$

If u_1 be the initial velocity and p_1 the initial pressure, this becomes

(21)

$$W = \frac{A\ p_1\ u_1}{RT}$$

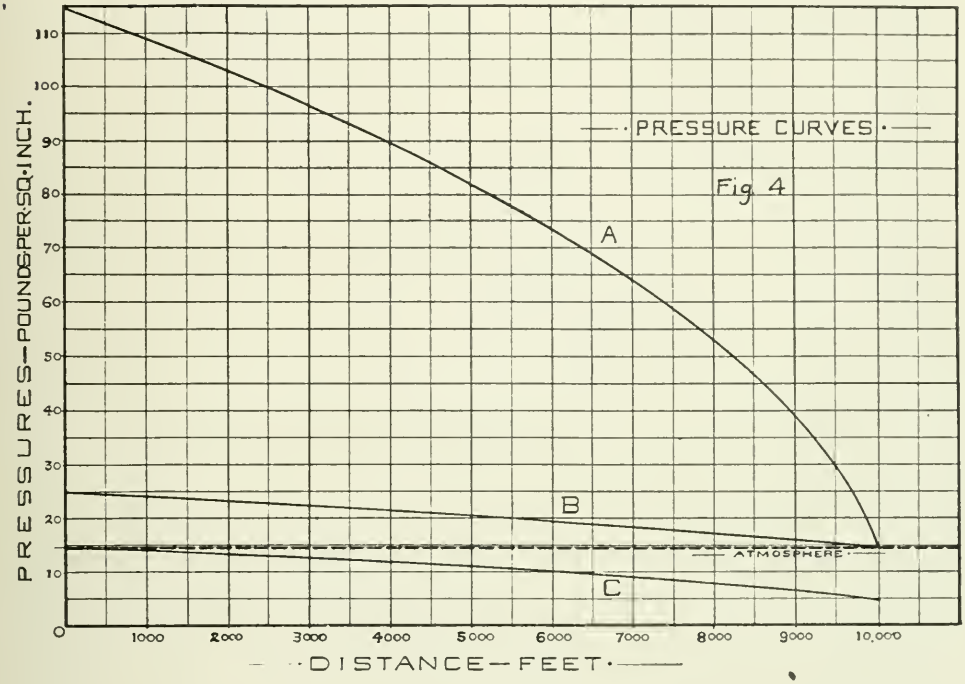
(22)

or $$W = 0.01478\ \frac{d^2\ p_1\ u_1}{461\ +\ r}$$

(23)

$$W = \sqrt{\frac{A^2 g d}{4\,\mathbf{f}\,RL\,(461+r)}\left(P_1^2 - P_2^2\right)}$$

Substituting for u_1 the value given in (12)



(24)

$$W = 0.30566\sqrt{\frac{d^5}{\mathbf{f}\,L\,(461+r)}\left(p_1^2 - p_2^2\right)}$$

The quantity of air flowing through a tube expressed in cubic feet per unit of time, at atmospheric pressure, is easily computed when the velocity at the open end of the tube is known.

A discussion of the coefficient **f** is deferred to Part II.

POWER.

From the foregoing formulæ an expression might be derived for the power consumed to maintain a constant flow of air, but in practice the source of power is usually some form of air compressor, and since there is more or less loss of work in the form of heat between the compressors and the tube, the power can best be computed at the air-compressing cylinder.

In the tube the air expands isothermally, but in the cylinder of most air-compressors used for the operation of pneumatic dispatch tubes, the compression is nearly adiabatic, since the pressure seldom rises above 15 lbs. per square inch, so that water jackets are not required and but little heat escapes through the walls of the cylinder. Between the compressor and the tube, or immediately after entering the tube, most of the heat of compression is lost.

Let v_2 = the initial volume of air compressed per minute.
v_1 = the volume of the same air after compression.
p_2 = the initial pressure.
p_1 = the final pressure.

Referring to Fig. 3, the relation of volume and pressure for adiabatic changes is expressed by the formula

(25)

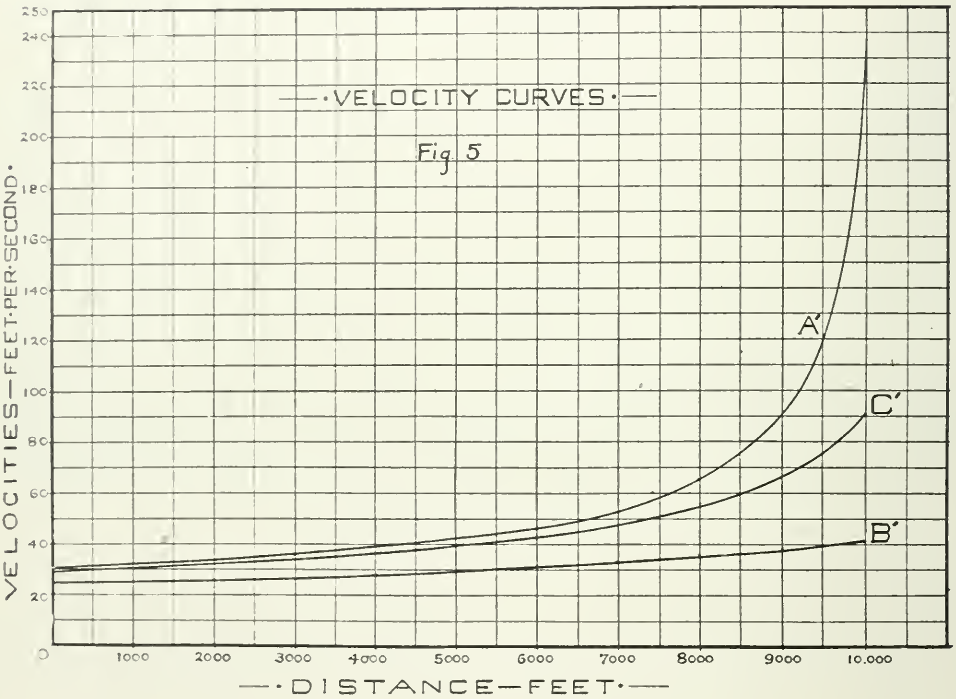
$$\frac{v}{v_2} = \left(\frac{p_2}{p}\right)^{\frac{1}{k}}$$

The general expression for E, the work done when the volume and pressure of a gas changes, is

$$E = \int_{p_2}^{p_1} v \, d\, p$$

Substituting for v its value in (25)

$$E = v_2 p_2^{\frac{1}{k}} \int_{p_2}^{p_1} p^{-\frac{1}{k}} \, d\, p$$



$$E = \frac{1}{1 - \frac{1}{k}} v_2 \, p_2^{\frac{1}{k}} \left[p_1^{1-\frac{1}{k}} - p_2^{1-\frac{1}{k}} \right]$$

$$E = \frac{k}{k - 1} v_2 \, p_2 \left[\left(\frac{p_1}{p_2} \right)^{\frac{k-1}{k}} - 1 \right]$$

For air, $K = 1.41$

Therefore:

$$E = 3.44 \, v_2 \, p_2 \left[\left(\frac{p_1}{p_2} \right)^{.29} - 1 \right]$$

This is the work represented by the shaded portion of figure, which may be considered an ideal indicator card of an air compressor.

Since one horse power is the expenditure of 33,000 foot-pounds per minute, the power necessary to do this amount of work in one minute is

$$H.P. = \frac{3.44}{33000} v_2 \, p_2 \left[\left(\frac{p_1}{p_2} \right)^{.29} - 1 \right] \quad (26)$$

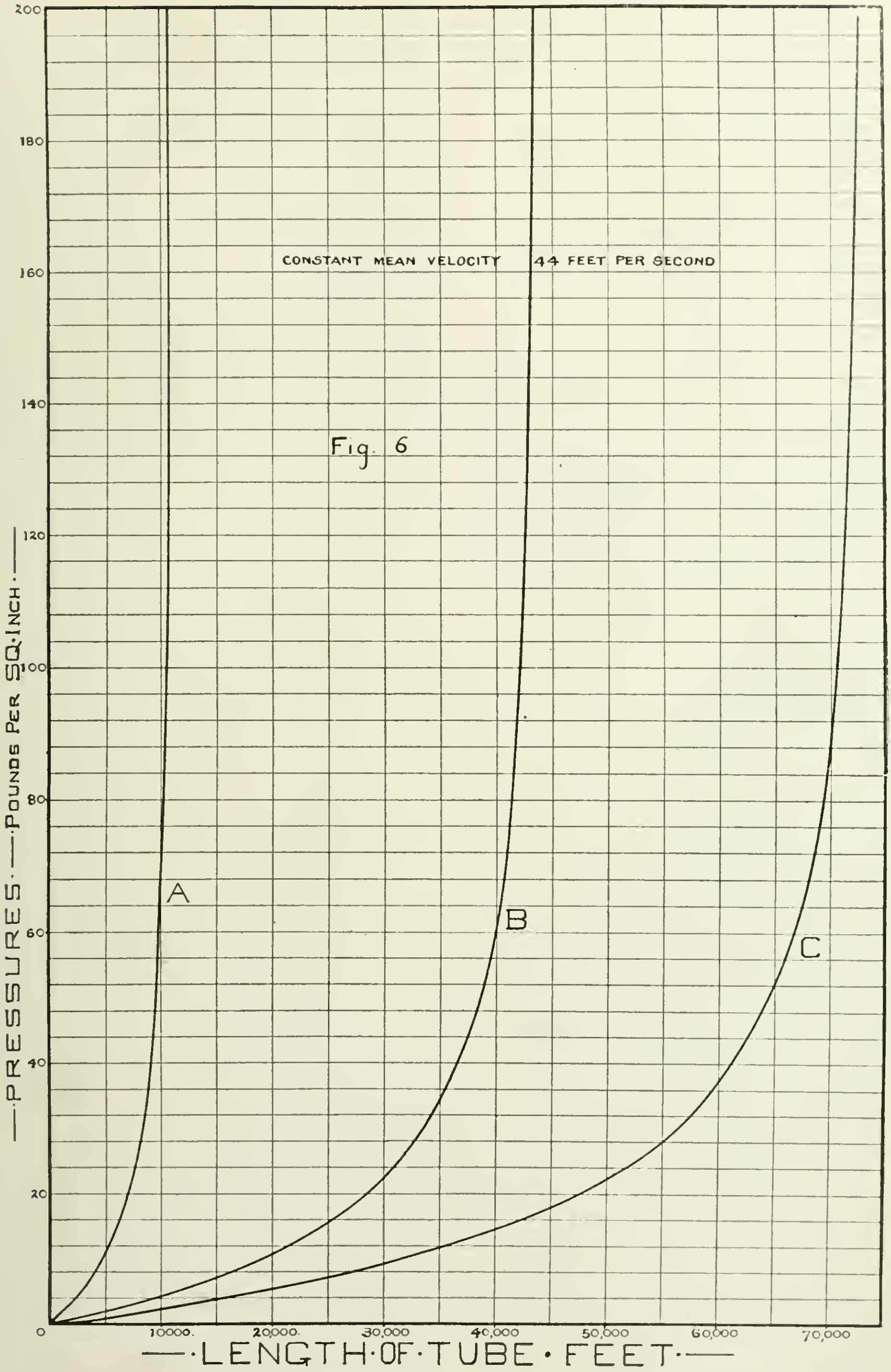
When v_2 is expressed in cubic feet p_1 and p_2 must be pounds per square foot.

Examples.

A few examples have been selected to illustrate the laws of the flow of air in long tubes, as expressed by the foregoing formulæ.

Pressure and Velocity Curves.

Imagine a tube ten thousand feet long, and suppose that a constant pressure of one hundred pounds per square inch be maintained at the initial end, and that the air be allowed to flow freely through the tube into the atmosphere at the far end. The flow will be constant and the temperature of the air in the tube is assumed to be constant. The following table


CONSTANT MEAN VELOCITY 44 FEET PER SECOND
Fig. 6
A
B
C
200
180
160
140
120
100
80
60
40
20
0
10000.
20,000.
30,000
40,000
50,000
60,000
70,000
PRESSURES — POUNDS PER SQ·INCH
LENGTH·OF·TUBE·FEET

gives the pressure and velocity of the air in the tube at each thousand feet along the tube:

100 pounds pressure.

Distance from Initial End. Feet.	Absolute Air Pressure. lbs. per sq. in.	Velocity of the Air. Feet per second.
0	114.7	30.38
1000	108.92	31.99
2000	102.80	33.89
3000	96.30	36.18
4000	89.33	39.00
5000	81.77	42.61
6000	73.42	47.46
7000	64.02	54.43
8000	52.95	65.80
9000	38.86	89.66
9500	29.38	118 60
10000	14.70	237.02

These pressures and velocities have been plotted (Figs. 4 and 5) and the curves A and A^1 drawn. The most striking characteristic of the pressure curve is its convexity upward being in fact an arc of a parabola. The pressure falls more and more rapidly as the open end of the tube is approached. The pressure curve of an inelastic fluid, like water, is a straight line.

The velocity curve A^1, Fig. 5, is more striking than the pressure curve. The initial velocity is about 30 feet per second. As the air flows along the tube the velocity increases gradually at first, then faster and faster until the open end is approached, where it rises to the maximum of 237 ft. per second. This example is an extreme case, purposely selected to show the variation in pressure and velocity. In practice a pressure as high as 100 lbs. per square inch would be impracticable.

For another example, assume a constant initial pressure of 10 lbs. per square inch, at the end of a tube 10,000 ft. long, the far end being open to the atmsophere. The following table gives the pressures and velocities along the tube as in the first example:

10 pounds pressure.

Distance from Initial End. Feet.	Absolute Air Pressure. lbs. per sq. in	Velocity of the Air. Feet per second.
0	24 70	24.61
1000	23.89	25.45
2000	23.05	26.38
3000	22.18	27.41
4000	21.27	28.58
5000	20.32	29.91
6000	19 33	31 45
7000	18.28	33.25
8000	17.17	35 40
9000	15.98	38.04
9500	15 35	39.59
10000	14.70	41 36

The curves B and B^1 (Figs. 4 and 5) illustrate this example graphically. In this case the pressure curve is almost a straight line slightly convex upward, and the velocity curve more nearly horizontal than in the first example. It is interesting to note that, although the initial pressure in the first example is ten times greater than in the second, the initial velocity is only about 20 per cent. greater showing how little effect an increase of initial pressure has on the initial velocity; on the other hand, it produces great inequality in the velocity at different parts of the tube.

Another example will be interesting showing the pressures and velocities when the air is exhausted from the tube—that is to say, for pressures below the atmospheric.

Assume a pressure of —10 lbs., or 4.7 lbs. absolute at the far end of the tube, the near end being open to the atmosphere. Under these conditions the current in the tube is in the same direction as in the previous case, but the power must be applied at the far end. Let the length of the tube be the same as before viz., 10,000 feet.

10 pounds vacuum.

Distance from Initial End. Feet.	Absolute Air Pressure. lbs. per sq. in.	Velocity of the Air. Feet per second.
0	14.70	29.02
1000	14.02	30.42
2000	13.31	32.04
3000	12.57	33.95
4000	11.77	36.25
5000	10.91	39.36
6000	9.99	42.72
7000	8.96	47.61
8000	7.80	54.67
9000	6.44	66.23
9500	5.64	75.66
10000	4.70	90.77

The variations of pressure and velocity are shown graphically in curves C and C^1 (Figs. 4 and 5). Curve C has slightly more convexity than curve B, otherwise it is similar. The velocity curve C^1 is considerably higher than B^1, showing clearly that with the same difference in pressure, much higher velocities can be obtained by exhausting the air than by compressing it. In other words, it is more economical to maintain a given speed of flow by exhaustion than by compression.

In the examples just cited the curves of pressure are independent of the diameter of the tube and of the coefficient of friction.

In the practical operation of pneumatic tubes it is sometimes desirable to know the initial and final velocity of the air, but more frequently the mean velocity between two given points is the quantity that is wanted, for it determines the time of transit. The mean velocity is computed by formula (18).

In order to show what initial pressures will be required to give a mean velocity of thirty miles per hour (44 ft. per second) in tubes of coefficient **f** vary with the diameter of the tube, various sizes and lengths, the following table has been computed and the results plotted in Fig. 6. Tubes having a diameter of 3, 8 and 12 inches have been selected to cover a wide range of sizes.

A constant air current is assumed with the far end of the tube open to the atmosphere.

Curves A, B and C are for 3, 8 and 12 inch tubes respectively.

3-ince Tube.		8-inch Tube.		12-inch Tube.	
Initial Gauge Pressure. Lbs. per sq. in.	Length of Tube. Feet.	Initial Gauge Pressure. Lbs. per sb. in.	Length of Tube. Foot.	Initial Gauge Pressure. Lbs. per sq. in.	Length of Tube Feet.
1.60	1000	0.38	1000	0.23	1000
1.41	2000	1.17	3000	0.69	3000
5.49	3000	2.01	5000	1.17	5000
7.95	4000	3.37	8000	1.92	8000
10.92	5000	4.35	10000	2.44	10000
14.68	6000	5.42	12000	2.98	12000
19.70	7000	7.18	15000	3 83	15000
26.96	8000	10.50	19707	10.50	32971
39.16	9000	23.	30377	23.	50824
67.56	10000	50.	38507	50.	64424
100.00	10412	100.	42127	100.	70482
200.00	10752	200.	43501	200.	72780

Limiting Lengths.

It will be noticed that the pressures increase much more rapidly than the lengths, especially towards the bottom of the table; and that the lengths are approaching a limit that can not be exceeded, no matter how great the initial pressure may be. In other words, for every diameter of tube and mean velocity there is a length that can not be exceded even though the pressure be infinite.

Transforming formula (18).

$$L = \frac{(31.027)^2\ Td}{f u_m^2} \quad \frac{(p_1^2 - p_2^2)^3}{(p_1^3 - p_2^3)^2}$$

$$L = \frac{(31.027)^2\ Td}{f\ u^2} \quad \frac{(p_1^2\ p_2^2)^3}{(p_1^3\ p_2^3)^2}$$

Let $p_1 =$ infinity; then

$$L_{\text{Limit}} = \frac{31.027Td}{f\ u_m^2}$$

(31)

which is the limiting length of tube, of diameter d through which air at temperature T can ce made to flow with a mean velocity u_m. It is the asymtote of the pressure curves of Fig. 6 which are drawn by plotting the pressures and lengths of the foregoing table.

The following table contains the limiting lengths of tubes from 1 to 144 inches diameter through which air can be made to flow with a mean velocity of fifteen, thirty and sixty miles per hour (22, 44 and 88 feet per second) computed by formula (31). (Values of the coefficient *f* vary with the diameter of the tube and in computing this table values given by Ulwin's formula have been used. See Part II.)

Diameter of Tube. Inches.	Mean Velocity 22 ft. per sec. Limiting Length of Tube. Miles.	Mean Velocity 44 ft. per sec. Limiting Length of Tube. Miles.	Mean Velocity 88 ft. per sec. Limiting Length of Tube. Miles.
1	1.32	0.33	.08
2	4.32	1.08	.27
3	8.48	2.12	.53
4	12.76	3 19	.80
6	22.72	5.68	1.42
8	33.40	8.35	2.09
10	44.52	11.13	2.78
12	55.88	13.97	3.49
15	73 24	18.31	4.58
18	90.34	22.58	5.64
24	126.	31.59	7.90
36	198.	49.53	12.38
48	270.	67.58	16 89
72	416.	104.	26.
96	560.	140.	35.
120	704.	176.	44.
144	852.	213.	53.

By an examination of the curves (Fig. 6) it will be seen that these limiting values can not be even approached. In practice pressures seldom exceed 15 lbs. per square inch and that pressure will only give a speed of thirty miles per hour in 3-inch tubes, not more than one mile long, while the limiting length for that speed is 2.12 miles.

An inspection of formula (31) shows that the limiting length varies inversely as the square of the mean velocity; therefore, for a mean velocity of sixty miles per hour the lengths are one-quarter as great as for thirty miles per hour. On the other hand, for a mean velocity of fifteen miles the lengths are four times greater.

As stated elsewhere, these are applications of the formulæ beyond the limits of experiment and therefore must be used with caution.

We have no experiments from which to compute the coefficient of friction, for tubes more than 12 inches in diameter, but it is interesting and instructive to apply our formulæ to larger tubes, for they are frequently proposed as a means of passenger and freight transportation.

Several experimental tubes sufficiently large for passenger traffic have already been constructed, and a 4-foot tunnel, about two miles long was built under the streets of London for transportation of mail. The formula shows that the limiting length of a tube 10 feet in diameter for a mean velocity of sixty miles per hour, is forty-four miles, but to obtain this velocity in a tube only nineteen miles long would require an initial pressure of 10 lbs. per square inch, consuming 20,330 horse power in the compression of 567,360 cu. ft. of air per minute—all this to move the air through the tube, to say nothing of the additional power necessary to propel cars or trains. It is quite evident that this would not be a practical method of operating a railway at high speeds for long distances, however successful it might be for short distances.

(To be continued.)

SOME IMPORTANT ELEMENTS OF ECONOMY IN THE STRAIGHT LINE AND DUPLEX TYPES OF COMPOUND AIR COMPRESSORS.*

By Lucius I. Wightman.

(Concluded from March.)

REDUCED PRESSURES AND TEMPERATURES IN THE AIR CYLINDERS DUE TO COMPOUNDING

Inversely the same things are true of the resistances and temperatures in the air cylinders. The pressure is not carried as high in the low pressure cylinder, and since in the high pressure cylinder the pressure at the beginning of the stroke is quite high, the delivering pressure is reached much earlier in the stroke. This pressure then continuing to the end of the stroke, there is a very uniform load on the piston all the way through and no great difference from beginning to end. The equalizing of the work at the two sides of the machine for both steam and air cylinders is accomplished in the original design of the machine by making the cylinders of the correct relative sizes. Since heat is a product of compression, the compounding of the air cylinders reduces the range of temperatures in these parts also, but this effect of compounding is more fully considered later.

MECHANICAL GAINS BY DOUBLE COMPOUNDING

Looking now at the air end, the phenomena and advantages of compound air compression are so well understood as to need no extended discussion here. It will be enough to emphasize the fact that in the air cylinders inversely the same things are true of pressures and temperatures as have already been noted in connection with the steam cylinders. The result is a reduction of the differences of temperatures and pressures in the air end, all tending toward an improved operation. The cutting down and transferring of the excessive uncompensated pressures in the cylinders from the extreme ends of the stroke, and their more uniform redistribution secured by this process of double-compounding, reduces the terminal and maximum stresses upon the bearings about 45 per cent, noticeably improving running conditions, making the lubrication easy and more effective, reducing wear, and giving great durability while still dispensing with the necessity for close attention.

THE STRAIGHT LINE CAN NOT BE SATISFACTORILY DOUBLE COMPOUNDED

Straight line compressors have been made with tandem two stage air compressing cylinders, and even also with tandem high and low pressure steam cylinders, but these arrangements have greatly complicated the machine, have increased its relative cost for the work it does, have made all the parts more inaccessible than before for adjustment, repair or replacement, and, after all, have left the machine, in its actual running, defective in its characteristic inability to run at slow speed, and to get the expected results at any speed.

FOUR CYLINDERS AN ELEMENT OF ECONOMY

In the duplex machine, as compared to the simple straight line type, while there is a simplification by a reduction of the number of parts as regards flywheel, crank shaft and connecting rods, there are four cylinders in place of two. But here is where one of the most important of the advantages of the duplex machine is found. It happens that this very arrangement at once provides the possibilities for the best economy both in the development of the power from the steam, and in the application of the power to the compression of the air, *simply by virtue of its four cylinders.* To use steam with the best economy, in this line of service, high steam pressure, compound steam cylinders, and a condenser should be used. These conditions, except the latter, may be provided for in new installations; the latter depends upon the water available. To compress the air to the usual pressures, and with the least expenditure of power, compound air cylinders with an efficient intercooler between must also be provided. An economical air compressor of the present day, can not, therefore, have less than two steam and two air cylinders; and if the duplex machine thus insists upon four cylinders, it insists only upon one of the most important conditions of practical economy in air compression.

THE ACCESSIBILITY OF THE DUPLEX

The accessibility of the parts of the duplex machine when running is most important, as it permits perfection of adjustment and prevents serious derangement or loss in economy by providing means for anticipating it. While in the case of the straight line machine some of the parts may be badly worn before any attention is given to them; and in general it may be said that the straight line has to refuse to run before its derangements will be attended to.

ADVANTAGES OF COMPOUND AIR CYLINDERS

The advantages of two stage air compression have perhaps been sufficiently insisted upon and do not need to be given any prominence here. By first compressing to nearly one-half the required load in a low pressure cylinder. then passing the hot resulting air through an efficient intercooler, so that the air enters the final cylinder at about original temperature the power required for the compression is lessened and the air is delivered in better condition for use. The intercooling of the air permits the interception of much of the moisture which it contains; and also the final delivery of the air at a much lower temperature than would result from single stage compression enables it to drop more of the moisture in the receiver. So that when it comes to be used it is practically dry air and gives no trouble from freezing up at the exhaust, or from washing out the lubricant. The reduction of the temperature of the air as it passes through the cylinders and the valve passages reduces the wear of the piston rings, cylinders, stuffing box packing and the valve surfaces by promoting better lubrication through the absence of moisture.

DUPLEX AND HALF-DUPLEX COMPRESSORS

The duplex machine is certainly no more liable to disabling accident than the straight line machine; and in many cases where a breakage or serious accident has thrown one-half of the machine out of use it may still be possible to run the high pressure side independently, when a straight line machine would have been completely laid up. The duplex machine may also be first installed as a half-duplex and run as a straight line machine until the increased demand for air warrants the installation of the second half. The installation of the latter then shows, in smoothness of running, in better speed control, and in higher economy, the advantageous features of the duplex type of machine.

THE DUPLEX A BALANCED STRUCTURE

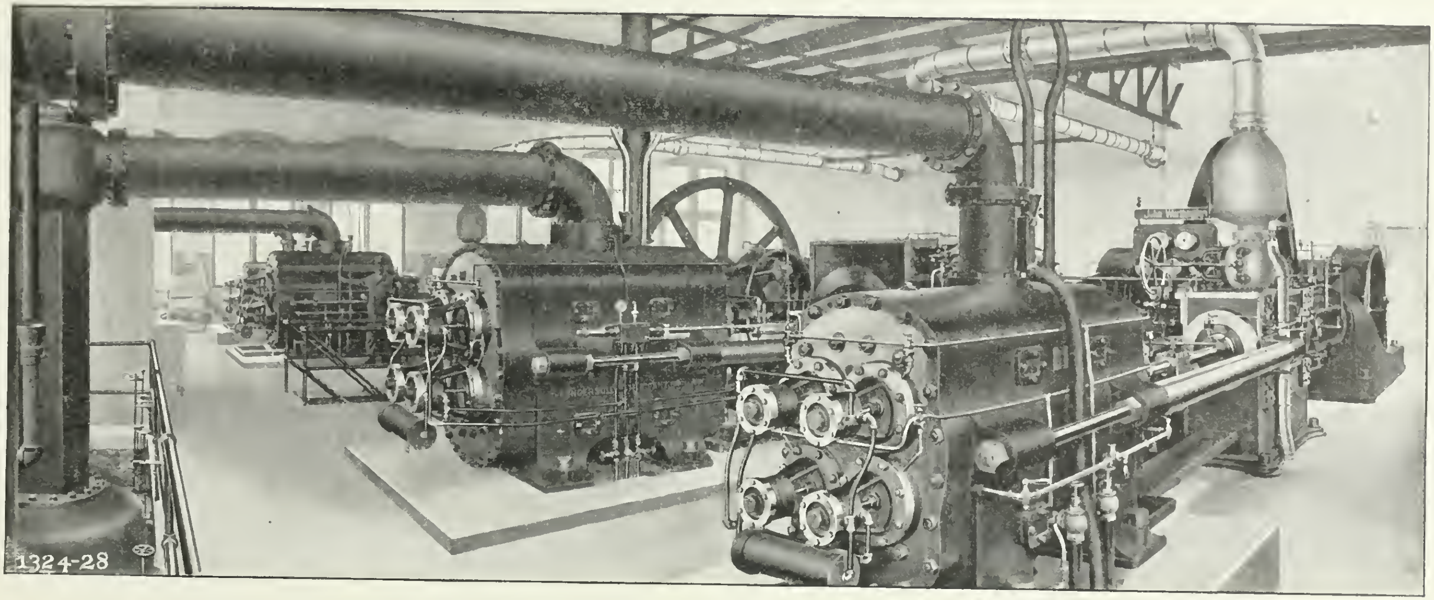
In the duplex compressor not only are the maximum stresses upon each side of the machine reduced, but they occur on the two sides at different times, and largely balance or compensate each other, the combined effect being to reduce the ultimate stresses, to minimize the wear and the chance of break-down, and to prolong the efficient life of the machine.

ALL COMPOUNDING ADVANTAGES POSSIBLE IN THE DUPLEX

The duplex compressor makes possible the compounding of the cylinders either at the air or steam end, or both, without additional complication. The cylinders are there, and in the precise relative conditions most suitable for compounding. Duplex compressors may be, and are actually made either duplex steam and duplex air, duplex steam and compound air, compound steam and compound air, or compound steam and duplex air. The third arrangement is of course the ideal combination for satisfactory and economical air compression, when steam and air pressures are not too low. The location of the cylinders and other parts relatively to each other, is precisely that most convenient for locating and connecting steam receivers, air intercoolers, aftercoolers, and other appurtenances. The attitude of the duplex machine is to invite, to make easy, and to promote the best practice in air compression. The attitude of the straight line machine, on the other hand, is just as distinctly to make difficult, and in some details, impossible, the same advanced and most approved practice.

A SUMMARY OF THE DUPLEX ADVANTAGES

It is really a striking array of advantageous features which can be brought out in favor of the duplex type of air compressor. The following may be recalled among them: greater economy in steam consumption; gains by compounding both steam and air cylinders; the maintenance of a more uniform air pressure; the delivery of dry air; automatic control and efficient lubrication; reduced leakages by the partial balancing of pressures; low friction of valves and pistons; sustained adjustment and tightness of vital parts. These may easily result in a saving of 30 to 40 per cent over the simple straight line machine, and of 15 to 20 per cent over the double-compound straight line. Then the reliability and perfect accessibility of every part, and the saving in supervision and maintenance are also to be considered in its favor. For the straight line it can be said that the first cost is perhaps less, the foundations required are less expensive, and the space occupied is small. The saving in operating the duplex machine will really cover the difference in these costs many times over and, before long, entirely pay for the machine.



LARGEST CENTRAL COMPRESSED AIR POWER PLANT FOR QUARRY WORK IN THE WORLD.

Interior View of the Power House of the Cleveland Stone Company, North Amherst, Ohio.

The two compressors shown have 20 and 44-inch steam cylinders and 39¼ and 24¼-inch air cylinders. Stroke, 48 inches. The air from the plant operates all the machinery in three quarries, one of which is the largest sandstone quarry in the world. This installation was described in COMPRESSED AIR for August, 1905.

A STATEMENT SUBSTANTIATED BY FACTS

This latter is but a plain statement of a simple fact, as may be easily demonstrated by referring to a specific case. The figures will actually show that the difference in the first cost of the machine and its installation is returned in a few months without any but the ordinary conditions as to fuel and labor costs.

PROOF IN A SPECIFIC CASE

Take an average case in which the power consumption is but 500 cubic feet of free air per minute, compressed at sea level to 90 pounds gauge. In a single stage compressor this will require 94 indicated horse-power: in a two stage machine, 81 indicated horse-power. A straight line compressor of this size is usually operated with a simple steam cylinder: and while such machines are usually equipped with Meyer gear permitting economical cut-off, yet the practical running conditions of a straight line are such that not one out of a hundred are, in actual service, run at less than ⅝ to ¾ cut-off. This is a fact of experience, and its result is that straight line machines of this size take, in everyday service, from 40 to 50 pounds of steam per horse-power hour and every well-informed engineer knows that they will require on an average 45 pounds of steam or water per horse-power hour. The duplex, having no "dead center," can be run conveniently at short cut-offs; and in ordinary compressor service, small units and moderate steam pressures, duplex compound steam cylinders will require about 28 pounds of steam per horse-power hour, non-condensing.

These relative figures are as fair to one as to the other—not the best that can be done, but what can actually be expected under ordinary conditions for a term of years.

OPERATIVE CONDITIONS

An average boiler plant will not do better than 7 pounds of water evaporated per pound of coal burned. A boiler horse-power is rated as 30 pounds of steam evaporated per hour. These are all average figures, and comparisons based on them are safe and fair to all.

Results in the present case may be tabulated thus:

Simple Air and Simple Steam: 94 indicated horse-power; multiplied by 45, equals 4230 pounds steam per hour; divided by 30, equals 141 boiler horse-power.

Two Stage Air and Simple Steam: 81 indicated horse-power; multiplied by 45, equals 3645 pounds of steam per hour; divided by 30, equals 122 boiler horse-power.

Duplex Two Stage Air and Compound Steam: 81 indicated horse-power; multiplied by 28, equals 2268 pounds steam per hour; divided by 30, equals 76 boiler horse-power.

OPERATIVE SAVINGS

Saving by Compounding Air End Alone (straight line or duplex) : 13 indicated horse-power; 585 pounds steam per hour; 19 boiler horse-power.

Saving by Compounding Steam End Alone (duplex cross-compound steam simple air) : 1377 pounds steam per hour; 46 boiler horse-power.

Saving by Compounding Steam and Air (duplex double-cross-compound *only*) : 13 indicated horse-power; 1962 pounds steam per hour; 65 boiler horse-power.

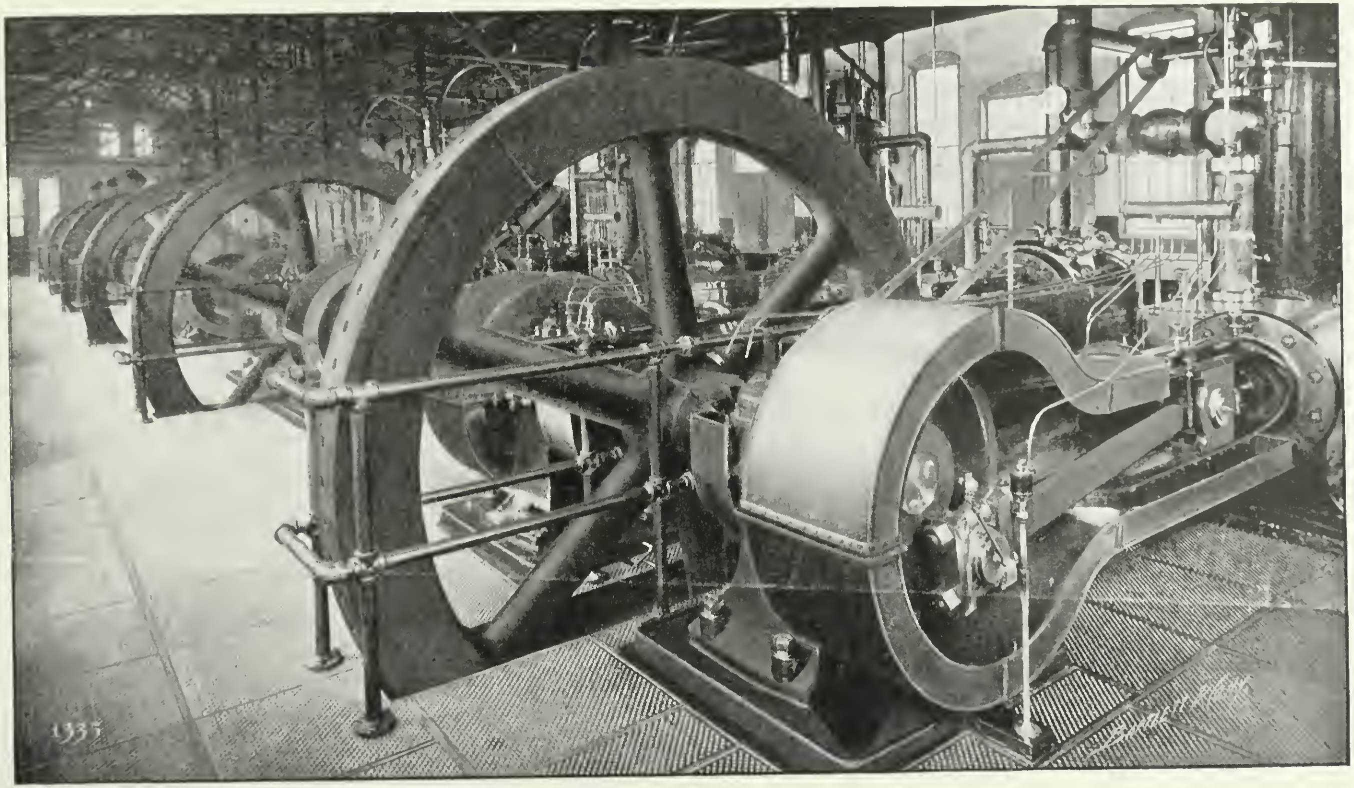
SOME INTERESTING DEDUCTIONS

These figures alone are enough to prove the case, but the buyer of machinery thinks in dollars and cents rather than in horse-power. He is, to be sure, interested in knowing that the duplex compound is "more economical of power," but he knows that "it costs more" than the straight line; and even a full knowledge of the fact that the straight line "double-compound" is mechanically inferior to the duplex or "double-cross compound" may not overcome his financial scruples.

But a complete compressor plant includes boilers and auxiliaries as well as the compressor; and boilers cost money; besides having a voracious appetite for coal. It has been demonstrated that a "double-compound" straight line is not a satisfactory machine; so further comparisons, reduced to money values, may be based on a simple steam two stage straight line and a "double-compound" of duplex type.

SAVING IN BOILER INSTALLATION BY THE DUPLEX

To use this straight line machine, 46 additional boiler horse-power, with larger piping, auxilares etc., must be purchased. The buyer referrng to his catalog table, will see 81 horse-power noted, but will not notice that this is *indicated* horse-power, and at a rating of only 30-45, or two-thirds of the *boiler* horse-power required. So he will probably buy a 90 horse-power boiler, force it up to 122 horse-



A BATTERY OF SEVEN AIR COMPRESSORS IN THE POWER HOUSE OF THE CAMBRIA STEEL COMPANY AT JOHNSTOWN, PA.

Steam cylinders, 20 and 32 inches; air cylinders, 28¼ and 17¼ inches; stroke, 24 inches. Total capacity of plant, 11,700 cubic feet of free air per minute.

power, and then wonder why it fires so hard. This same inference made in buying a "double-compound" would have resulted in getting a good, easy-firing boiler, probably never loaded to its full capacity. The simple steam straight line, therefore, must be charged up with the cost of 46 additional boiler horsepower, with necessary auxiliaries. If their price installed is put at the moderate figure of $10.00 per horse-power, not including cost of auxiliaries and larger piping, there is a total of $460.00, which, credited to the first cost of the duplex double-compound, does not make the latter look so dear after all. In this particular size of compressor it will probably more than cover the difference in price of the two types. Those are installation charges appearing in the items of "first cost."

SAVING OF WATER BY THE DUPLEX

Looking now at the operating charges, it will be noted that 1377 pounds less water per hour is required by the duplex compound. This is 1650 gallons per 10-hour day. In some places water charge is a serious item; at 30 cents per thousand gallons this compressor saves in water about 50 cents a day, or $150.00 per year of 300 days. When water is bad, the less there is to be handled the less boiler repairs involved. In a larger plant, the labor of a fireman may also be saved.

SAVING OF COAL BY THE DUPLEX

The value of the water saved is important, but the amount of coal otherwise needed to evaporate this extra water is still more important. At 1 pound of coal per 7 pounds of water, evaporated, this 1,377 pounds would require 197 pounds of coal per hour, or 1,970 pounds per day of 10 hours. With coal at $4.00 per ton, this is $3.94 per day or $1,182.00 per year of 300 10-hour days. The amount saved by the use of the duplex cross-compound in fuel and water, therefore, is $1,332.00 per year. In five years this amounts to $6,660.00; and if the plant runs double-shift the figure is doubled. Further, as these figures are based upon only 500 cubic feet capacity, it can be estimated approximately for larger volumes. For example, 750 cubic feet equals one and one-half times, 1,500 cubic feet, three times these figures, etc.

WHERE IS THE ECONOMY OF THE "CHEAPER MACHINE"?

Where, now, is the economy of "the cheaper machine"? Even with coal at $2.00 per ton, or only half the figure assumed above, the saving per year in fuel and water appears at $741.00; and the duplex compound is obviously the thing, for this amount will more than overbalance the difference in cost between the two types. Even at this fuel rate its total first cost would be saved in a few years; it would pay to throw out a once a less efficient machine. When coal is at all expensive, it is evident that the buyer should go on to the most refined Corliss type of compressor, running on only about one-half the fuel required by even the good duplex double-compound used in the example—and 500 cubic feet per minute is not a large machine.

It must, however, be kept in mind that to secure these savings it is not enough that a compressor be of the "double-compound" type: but it must be a thoroughly high-class and really economical machine, well and properly designed, and well built. As there are good watches and cheap watches, so are there degrees of quality in all things. As a matter of fact, a really high-class straight-line compressor has been shown by accurate tests actually to deliver its output of air at less fuel cost than duplex compounds which, on the outside, bear the appearance of economical design, and are even sold under "guarantee." Guarantees are of little protection, for once the expenses of foundations, piping, installation, etc., are incurred, and the work has become dependent upon the continued use of the air, tests are not made once in a thousand times; a condition exists of which the average manufacturer is quite willing to take advantage even with impossibe guarantees. If economy is really wanted, it can safely be expected and maintained only in constructions of the highest standard.

The tendency in all power installations of to-day is toward higher economy. Long strides have been made in this direction in recent years, and future progress must consist in a close attention to the smaller economies. It has been shown here how a mere difference in the type of compressor may affect the operating cost of a plant. The wide-awake manager is looking for just such facts as are here set forth, and this discussion should be of assistance in the selection of an efficient air-power equipment.

NEW APPLICATION OF COMPRESSED AIR.

One of the most remarkable applications of compressed air has recently been made by Mr. Phillip Brasher of Brooklyn, N. Y. This is nothing less than applying it for the purpose of protecting objects from wave action, for which he has taken out a basic United States patent.

Mr. Brasher first turned his attention to the study of waves and their effects when he was managing the Parkway Baths at Brighton Beach in 1901. Here there was a bulkhead of considerable length which had been built with no saving of expense but with due regard to the power of the waves. The framework was 15 inch to 18 inch piles joined by 12 by 12 inch timbers, the face consisting of a double layer of 4 inch grooved sheathing, the joints bebeing broken. All timber and piles were creosoted and the bulkhead was backed by a fill of rock, ashes and dirt and when completed should have apparently held back two oceans. But, alas! for the power of mere wood and steel when pitted against the force of ocean waves. Forty feet of bulkhead sheathing was torn away in one night under the action of a fairly heavy sea, leaving only piles and stringers. This was very discouraging, as the repairing of the break of such dimensions meant slow and expensive work. The break was situated at about the center of the structure, and the fact that the bulkhead ruptured at this place was very peculiar as much heavier seas had beaten against it before without doing any damage. But if a wave lands on an object just right, something has to give, and that something is not always the wave. Mr. Brasher began to wonder what could be done to solve the problem, for it seemed to be reducing itself to the old riddle, "if an irresistible force meets with an immovable object, what will happen?" And in the case of the bulkheads, it appeared as though the immovable object was getting the worst of it. In fact, the whole system of breakwaters and bulkheads seemed to be wrong, for they simply opposed force to force and were fighting effect instead of overcoming cause. In treating disease a physician tries to get at the root of the trouble and, if possible, stop the trouble at the start. It seemed therefore that much could be done in the case of fighting waves by breaking them up instead of allowing them to break up the bulkhead.

Now as to means. Anything on or near the surface would be exposed to constant hammering. so, obviously, the strategic point would be some place below the wave action and therefore safe from its destructive force.

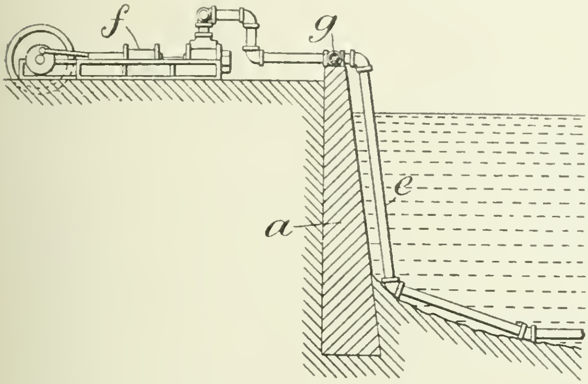
And now as to the wave itself. What gives it its power and what is its mode of travel?

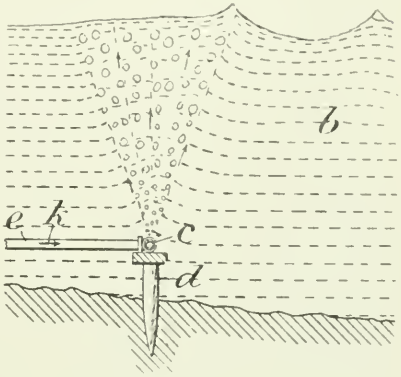
There is only one time at which a wave is really dangerous to anything substantial, and that is just as it is curling to break. It is then undergoing a change from what is called an oscillatory wave—or one whose particles merely oscillate, to a wave of translation—one whose particles *travel* along in a certain direction. At that particular time, the momentum attained by the tons of water, elevated to whatever height it may be, and falling from that height, is practically irresistible. So that if it is possible to cause a wave to break *before* striking any object to be protected, the capacity of the wave to do harm, is destroyed and it becomes merely a bubbling mass which looks rough but is really harmless.

Wave motion is described as the transference of energy by vibration: in other words, each particle of the wave merely vibrates and the motion is carried forward by the impact of the vibrating particles. A definition of a wave, given by Anthony and Brackett's "Physics" (page 140), is as follows:

Waves.—When a disturbance is set up at a point in the free surface of a liquid, it moves over the surface of the liquid as a *wave* or series of waves. Each wave consists of a crest or elevated portion and a hollow or depressed portion of approximately equal length, and the distance from a particle at the summit of one crest to a particle at the summit of the next succeeding crest, or the distance between particles in successive waves which are in the same condition of motion, is called a *wave length.* A line which is drawn along the crest of any one wave or through the particles in that wave which are in the same condition of motion, and which at every point is at right angles to the direction in which the wave is propagated, may be called the *wave front.*

The formation of waves is explained by inequalities of hydrostatic pressure arising in the liquid if by any cause one part of it be elevated above the rest. H. and W. Weber examined the peculiarities of waves in water and the motions of the water particles in them by the aid of a long trough with glass sides; by immersing one end of a glass tube below the surface, raising a column of water in it a few centimeters high by suction, and allowing it to fall, they excited a series of waves which proceeded down the trough and could be examined through the sides. The motions of the particles in the wave were studied by scattering through the water small fragments of amber, which were so nearly of the same specific gravity as the water that they remained suspended without motion except during the passage of the wave, and took part in the motion excited by the wave as if they had been particles of water. It was found that the wave motion transferred from one portion to another of the water, and did not involve a displacement of the particles concerned in it, —at least when the successive waves had the same length. In that case—which is the typical one—the particles in the surface of the water described closed curves, which were elliptical or circular in form, the diameter of the circle being equal to the vertical distance between the crest and the hollow or the height of the wave. In the upper part of the circle the particle moved in the direction in which the wave was moving, in the lower part of the circle in the opposite direction. The velocity of the wave was found to be dependent on its height and on the period of oscillation in the wave, and to be independent of the density of the liquid. The disturbance of the liquid by the wave is not merely on the surface, but extends to a considerable depth; as the depth increases the elliptic paths of the particles approach more and more closely to short horizontal lines.





The theory of these waves is extremely complicated, and has not yet been satisfactorily worked out; but we can indicate in a general way their causes and the mode of their propagation. Imagine a small hillock of water elevated at some point in the surface, and consider a particle at the base of this hillock: the hydrostatic pressure arising from the elevated column near it will tend to move it upward and outward from the center of the hillock. It will accordingly begin to move in the upper half of its circular path and in the direction in which the wave is propagated; the precise form of its path being determined by the changes of pressure which it experiences and by its inertia. Since the pressure which sets it in motion will be different for different heights of the hillock which gives rise to it, the velocity of the particles, and therefore also the velocity of the wave, will depend on the height of the wave, being greater as this is greater; the velocity of the wave is also greater as the wave length is greater. Since the pressure behind the particle and the inertia are both proportional to the density of the liquid, it is evident that the acceleration of the particle will be the same under similar circumstances, whatever be its density, so that the velocity of the wave should not depend on the density of the liquid.

The form of a wave is greatly modified by the character of the channel in which it moves, on account of the motion of the particles extending to a considerable depth, and on account of their viscosity. On the free surface of a large and very deep body of water the successive waves have the same form; the slope of the crest is a little steeper than the slope of the hollow, and its length is less than that of the hollow. As the depth decreases, the slope of the front of the crest becomes still steeper because of the restraint which then is imposed upon the movement of the particles in the lower half of their paths, and at last the forward motion in the crest so much predominates that the wave curls over and breaks."

An actual demonstration of the effect of compressed air on wave motion can be observed at several points above the tunnels which are being run under the river from New York City. The compressed air used in the tunneling escapes in various ways and rises, sometimes after quite a long journey through fissures or strata, to the surface, producing—particularly if there is a considerable amount of air—a complete elevation of the water directly above the escaping columns and a tremendous disturbance of irregular bubbles. Waves which imping on this disturbed area, collapse like balloons which have been pricked with pins. In this case the discharge of the air is not scientifically arranged, but even under these disadvantages the effect is absolute and undeniable.

Now as to the uses. In the first place, consider a disabled ship drifting on to a lee shore. She could simply throw out a sea anchor to which was fastened a distributing pipe for the compressed air and which could be held far enough away from the ship by means of a secondary anchor. Thus protected, the ship could lie in perfectly smooth water till repairs were made or the sea subsided. In the same way, stranded vessels could be protected from the pounding of the waves, till floated. Lightships could be surrounded by a circle of pipe and lie in the center of an absolutely calm surface. A space in front of life-saving stations could be covered so that lifeboats could be launched and started, for once started they could brave almost any sea. Bulkheads and breakwaters already built, could be afforded absolute protection by means of parallel pipe in front of them at a suitable distance, and artificial harbors could be constructed by simply running a line of pipe between two projecting headlands, and, the writer, believes, that in the not distant future there will be harbors constructed in the middle of the ocean, in vicinities of more than ordinary roughness, by means of pipes suspended from a series of floats so placed that both floats and compressor will be protected from any danger of wave action.

Mr. Brasher expects to establish an experimental station sometime during the coming summer, in which he will use various kinds of pipe, placed in various positions and under all conditions, in order to discover the most efficacious system under varying conditions. As the complete cotinuity of the particles is absolutely essential to wave motion, the position and kind of pipe which most completely destroys that continuity, is the one which will give the greatest satisfaction.

RETURN AIR.

The fact that compressed air does not condense and disappear as steam does, gives it a great advantage in its employment for intermittent and occasional work, says *Cassier's Magazine*. This advantage is fully appropriated in the air brake and in switch and signal work, where the air charges nothing for standing always ready, but only for work actually done.

The same condition of advantage should apply also in making available the elasticity or expansive force of the air, but in this field little progress has been made. The earliest general applications of compressed air were, and some of its developments of highest usefulness even to-day are still, self-evidently extravagant and wasteful. Attention has been called over and over again to the enormity of using air for driving the ordinary steam pump, from the fact that on the completion of each stroke the cylinder is entirely filled with air at the full pressure of the supply, whether this full pressure is required for the work or not, and the air is then thrown away at that full pressure with none of its expansive force made use of. The same waste of air practically occurs when the ordinary rock drill, of whatever make, is driven by compressed air. The air there also is discharged at full pressure, and, so far as power development is concerned, it might as well not be elastic.

The return air systems, which may be said to be only in process of development to-day, with the possible applications not as yet all thought out, seem to promise phenomenal results as compared with established practice. Return-air is the winning feature of the electric air drill. The return-air pumping system seems to be the most complete and convenient example of the transition from the old to the new. The raising of water by the direct pressure of air long seemed the most hopeless case of all. When compressed air has been admitted to the top of a chamber which is full of water, when the water has been driven by the air pressure up a pipe to some higher level of delivery, and when it then becomes necessary to get rid of all the pressure in the chamber, so that water will again flow in and fill it, what is there to do but to let the air escape into the atmosphere?

There has been but the one self-suggesting answer: open the valve and let the air go. We have had for a generation or two various devices all operating upon the same general principle of driving the water out and up by the direct pressure of the air and then letting the full pressure air escape. While this has been so long the only apparently possible answer, it has, of course, never been satisfactory, and the general use of air pressure for raising water has not extended rapidly on account of the cost of operation.

The real, up-to-date and more satisfactory way of answering the question is the asking of another: Why not, instead of letting the air escape into the atmosphere, pipe it back to the intake side of the iar compressor? There is no "why not," and this is accordingly done with most satisfactory results, transforming the wasteful device into one without that reproach.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

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FORTUNE is not always on the side of the publisher. In fact, he seems to have a surfeit of the other thing if our recent experience is any criterion.

It has been our endeavor that COMPRESSED AIR should make its appearance as close to the tenth of the month of publication as possible, but recently it has been coming out nearer to the tenth of the month *after publication*.

Labor trouble is responsible for this, a strike among the linotype operators, who have most to do with setting up the reading matter of the paper, having caused us much exasperation and delay.

These troubles are now, happily, over, and we hope that in the future COMPRESSED AIR will make its monthly appearance with more regularity and dispatch.

EDUCATION OF ENGINEERS.

In the October issue of COMPRESSED AIR we published an editorial on this subject in which we pointed out that, with the exception of New York University, there were practically no colleges in the country giving courses in the theory and practice of compressed air. We are now in receipt of a letter from H. J. Thorkelson, Assistant Professor of Steam Engineering at the University of Wisconsin in which he states that for some time past his department has been delivering lectures and giving practical instructon in this most important subject.

A synopsis, furnished by Professor Thorkelson, of his courses is most interesting, showing as it does, the thorough manner in whch the subject is covered. The first lecture consists of an historical account of the development and uses of compressed air and is followed by three or four lectures on air, its nature and composition. This includes the thermodynamics of perfect gases as applied to air in adiabatic and isothermal changes. Such terms as "free air" and dry air" are explained, and charts given to the students showing graphically the temperature change as air is compressed, also the work required to compress a given amount of free air to various gage pressures. This leads to a discussion of the ideal method of securing compressed air.

The above might be termed preliminary work, and is followed by a discussion of disc, centrifugal and positive volume fans and blowers, their theory and the formulæ required for calculating the capacity, and horsepower of these different types. Compound fans are next taken up, after which the subject of piston compressors is considered. In doing this the multi-stage system of compression is explained, and the use and construction of intercoolers, afercoolers and other attachments. The various types of piston compressors such as the "Straight Line," "Duplex" and other forms are illustrated, together with valve details and computations. Regulators, unloading devices, etc., are studied, after which the hydraulic system of compressing air is taken up. This subject is discussed by studying the details of construction from the most successful installations.

The work is then followed by the subject of pipes, and pipe transmission, with calculations for friction and other losses as well as some of the more important practical details of designing and installing pipe systems.

The rest of the course is devoted to a study of compressed air as applied to pumping, pneumatic tools, caisson work, tube transmission, street cars, air brakes, signalling and other uses; the description of many of these subjects beng supplemented by the actual operation of tools in the lecture room.

With the new material and lantern slides which are constantly being added to the equipment of the University, it would be hard to see how this course could be made more comprehensive and useful. We consider the University of Wisconsin should be congratulated upon taking the initiative in furnishing students of engineering with a foundation by which their work in after life may be made considerably easier, especially if it brings them into contact with pneumatic machinery.

THE CAPITALIST.

The worthy gentlemen in this country who are giving themselves so much concern because of the existence of the capitalistic class, says the *Army and Navy Journal,* would do well to study the explanation given by Herr Waldemar Schutz, a German who has been seeking an explanation of the poverty and starvamous possibilities of wealth. In an article in the Gegenwart of Berlin, translated in part by the *Review of Reviews,* he finds the explanation of this anomaly in the fact that the mechanical work of India is done by exclusively individual labor and not by the combined labor of individuals under the direction of capitalists. "In Europe and America the ideal business man is an individual who is intimately acquainted with all branches of his profession and who is constantly in touch with the developments of his particular line, one who selects his men so that each workman will be given work he is best qualified to do; who studies the market demand for his goods, and so forth. And it is clear that when business is conducted in this way it will probably produce a more perfectly developed organization than when it is controlled by an uneducated workman who has mere dexterity of hand at his command. In India the control of trade is in the hands of people who have no opportunity to study new methods of production, no way of seeing new mechanical tools, no possibility of studying market fluctuations, and who, because of their very independence, cannot be given the work for which they are best qualified." But there are indications of a change in India, and while we are proposing to inaugurate the millennium by killing off the capitalist, India is hoping for his advent that he may organize her industries and make them effective for the increase of her wealth and the substitution of general comfort for the wretched poverty which is the lot of the lower class Indian. The organization of modern commercial and industrial society seems to us to run parallel with the growth of what its critics call militarism. It vastly increases the power of the mass as well as the efficiency of the individual, while depriving him in a measure of his untamed freedom of action. Those who have so much to say about the rich growing richer and the poor poorer under our system would do well to compare our average condition under cooperative labor with that of the three hundred millions of India who have not yet developed the system of capitalized organization.

A novel feature in tunnel design devised by Mr. Chas. M. Jacobs, the chief engineer to the Pennsylvania tunnels under the Hudson River, is found in the screw piles, which will be placed at intervals of 15 feet throughout the length of the tunnels. While the silt forming the bed of the river is sufficiently tenacious to hold the tunnels in perfect alignment during construction, it was not considered firm enough to do so when the tunnels are in use. To forestall this possible danger, screw piles will be sunk to a solid foundation, and upon them the tunnel proper will rest. The piles will be 27 inches outside diameter, and the shell will be 1¼ inches thick. The sections will be 7 feet in length, and will be bolted together through internal flanges. The lowest section will be cast with one turn of a screw 4 feet 8 inches in diameter.

The "shell," or jacket guides, of a rock drill, when worn, allow the machine too much play, which is likely to break the feed screw and considerably affects the efficiency of the machine, inasmuch as it will waver slightly, each blow of the drill increasing the friction and thus reducing the efficiency.

NEW PUBLICATIONS

Modern American Lathe Practice, by Oscar E. Perrigo, M. E., 416 pages, fully illustrated, published by The Norman W. Henley Publishing Company, New York; price, $2.50.

This work is certainly a very complete treatise on the subject of the modern lathe, its design, development and use, and will doubtless meet with great favor at the hands of engineers and mechanics. The book opens with a chapter on the history of the lathe, up to the introduction of screw threads, and then traces its development from that time to the present. This is followed by a chapter on the classification of lathes, in which the author divides them into four general classes, with eighteen subdivisions of these classes, giving a short description of each. The chapters covering lathe design are most complete and occupy approximately 130 pages, practically every part which enters into the construction of a modern lathe being treated in greatest detail. The rest of the book, some 200 pages, is taken up with lathe practice, high speed cutting tools, proper feeds and cutting speeds, testing lathe, turning tapers, crank shafts, boring cylinders and other important work. The book should be of great value to shop men in general, as it is the only complete work ever written upon the subject, and contains a vast amount of valuable information.

TRADE PUBLICATIONS

Kilbourne & Jacobs Manufacturing Company, Columbus, Ohio.—Catalog No. 36, 6x9, 96 pages, devoted to a full description of the mine and industrial railway cars which this company manufactures. Among the cars included in the catalog are various dump cars, rocker cars, ash cars, contractors' cars, cable bottom cars and cars for coke ovens, foundries and manufacturing plants.

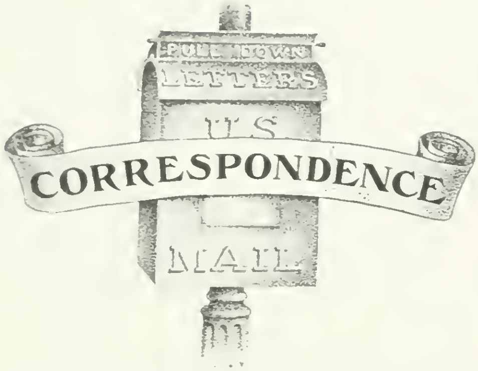
Baldwin Locomotive Works, Philadelphia, Pa.—Record No. 60, 6x9, 32 pages, entitled "The Actual Efficiency of a Modern Locomotive." This booklet takes up the subject of theoretical efficiency, first costs, interest on investment, depreciation in value, fuel, supplies, estimated cost of cylinder and engine oil per 1,000 engine miles, hauling capacity and cost per ton mile, etc. It is a most interesting and valuable booklet for any one to possess.

Weston Engineering Company, 56 and 58 Pine street, New York—Handsomely printed catalog, 22 pages, 9x12, profusely illustrated, describing the Blake-Denison Continuous Weigher, for weighing material handled by conveyors. This apparatus automatically weighs and records the quantity of ore, coal or other material passing over any conveyor, giving a continuous record of the aggregate net weights. A record that can be consulted hourly, daily, weekly or as may be desired. It is claimed that it will weigh within one-half of one per cent.

Word Brothers, 60 Castro street, San Francisco, Cal.—Small booklet, 24 pages, devoted to a description of the Word Brothers' Drill-Maker and Sharpener, which forges and sharpens all styles of rock drills up to 10 feet in length, while their special machine accommodates drill steels up to 40 feet in length. These machines will sharpen from 600 to 800 steels per day and will forge from 500 to 700 new drills per day from blank steel bars.

Joseph Dixon Crucible Company, Jersey City, N. J.—Souvenir book, 6x9, 40 pages, entitled, "Crucibles, Their Care and Use," by John A. Walker. This book should be in the hands of all interested in the melting of various metals, as it instructs the users of crucibles as to their proper use and the danger of abuse of crucibles. It tells what graphite is and why crucibles are made of it. This work was prepared by Mr. John A. Walker, vice-president, treasurer and general manager of the Joseph Dixon Crucible Company, who is thoroughly fitted by long years of experience in crucible making to be regarded as an authority on the subject.

THE Hurry and Seaman compressed air device for cement has superseded the natural draft system at the plants of the Lehigh Portland Cement Co., says the *Engineering Record.* The latter system, in which very high stacks are utilized in order to get the draft, was invented by Mr. Chas. A. Matcham, the former general manager. Col. Harry C. Trexler, president of the Lehigh compony, states that the Hurry and Seaman method was installed due to the fact that the natural draft system did not come up to expectations, either in economy or in efficiency.



To the Editor of Compresser Air:

Dear Sir—I have at hand my first copy of Compressed Air, with which I am very much pleased. I wish to ask if you answer practical questions through the medium of your paper, such questions for instance as the following:

What is the reason that heavy flywheels are used on single stage compressors?

What should be guarded against in lubricating the air cylinders?

What advantage is there in multi-stage compression?

Simple questions, no doubt, to some, not so to others. An answer to these questions and others along the same line would be very much appreciated, if it is your custom.

T. F. Haggart.

The reason that heavy flywheels are used on single stage compressors is due to the fact that in these machines when the piston is at the end of the stroke the pressure in the steam cylinder is at its lowest point, while the pressure in the air cylinder is at a maximum; it is therefore necessary to make the flywheel extra heavy in order to carry the machine over this point.

In a duplex compressor, where the cranks are quartered, heavy flywheels are not required, as the steam pressure in one steam cylinder is at a maximum when the steam pressure in the other steam cylinder is at its lowest point.

In the lubrication of air cylinders care should be taken to use only oil of light body and high flash point, and, under no circumstances should kerosene be introduced into the cylinder. If trouble is encountered, due to sticky discharge valves, these should be removed from the cylinder and cleaned with soap and water. If it is not practicable to shut down the machine, soap suds may be fed to the cylinder through the lubricators, and then the machine run on oil for a short time before shutting down, to prevent the valve rusting. It is very good practice to feed soap suds into the air cylinder for a couple of hours each week in order to keep the valves from becoming gummed up.

The advantages of multi-stage compression are so many and so great that it is possible to write a book on the subject, and we should like to refer you to any good work on compressed air, such as Saunders' Encyclopædia of Compressed Air Information, Richards' Compressed Air, etc. Briefly, however, there is a gain of about 15 per cent. in a two-stage over a single-stage air compressor when operating within the usual range of pressures. This is due to the fact that air as it is compressed becomes heated and therefore occupies a greater volume than it would if cooled. The compound air compressor cools the air after it has been partially compressed, and it consequently enters the high-pressure cylinder at its original temperature, so that its final temperature upon compression is considerably lower than if it had been compressed in a single-stage machine, and a greater volume of air may be compressed at an expenditure of the same amount of power.

RESCUE WORK IN MINES.

Reference was made in a previous issue to the activity in mine rescue work. We are now able to announce that a new liquid air rescue apparatus, embodying an altogether new principle in regenerative appliances has been perfected. It is known as the "Aerolith," and the entire apparatus, weighing only some 14 lbs. can be easily carried on the back. The claim is made that it will give an absolutely pure and cool air supply during three hours' working, and there is the advantage that its use calls for no special training on the part of the miner. The apparatus is to be made the subject of exhaustive tests in England, one of the appliances having been purchased by the Royal Commission on Accidents in Mines for that purpose, and a large liquid air plant has been installed at the Rothschild Mines in Austria. Authoritative pronouncement as to the real utility of the apparatus is likely, therefore, to be forthcoming in the near future.

CHIPPINGS.

A novel and improved fog signal is just installed at the Needles light-house, Isle of Wight. It consists of a set of reed trumpets, worked by compressed air, and can be started instantly when fog descends, giving a blast five seconds long every fifteen seconds, which can be heard ten miles—treble the distance of the old fog-bell signal.

Compressed air is still more extensively used than electricity as the motive power for coal-cutting in Great Britain. In 1905, there were 555 compressed air machines, while only 355 electric machines were in use. However, the latter are making greater strides than the former, for out of the year's increase in the number of machines in use, 85 were driven by electricity and 70 by compressed air.

The pipe system, which serves to supply compressed air to the various stations for the use of the locomotives in the plant of the Washoe Copper Company, is composed of pipes varying from 6 in. to 2 in. in size. Even at the high pressure of 800 to 900 lb. per square inch it has developed practically no leaks. The air is furnished by two four-stage compressors, having cross-compound steam cylinders, equipped with Corliss valve gears. The compressors are provided with automatic regulators to insure constant high-pressure air.

COUNTING REHANDLED MATERIAL TWICE.

More than 13,000 tons are handled daily at the than 13,000 tons are handled daily at the Washoe smelting works, Anaconda, Mont., by 13 compressed-air locomotives, 12 of which weigh 13 tons each, and one 21 tons. Each locomotive carries two storage tanks for its air supply, the air being taken from a pressure system of pipes laid conveniently to the tracks, and having stations at which the locomotive stops to get its air supply. This supply is carried at from 800 to 900 lbs. pressure per square inch. A reducing valve between the storage tanks and the cylinder reduces the pressure to 150 lbs. A fresh supply of air is taken at times ranging from 20 to 60 minutes. For this particular service, where the distances are short, and where the cars are frequently stopped and started, the compressed-air locomotives have been found most satisfactory for convenience, reliability and simplicity of operation. They have been in constant service since 1900, and have needed only the natural running repairs.—*Engineering and Mining Journal.*

Recent experiments in France have developed a new respiratory apparatus for underground work. It consists of an india rubber bag, worn in front about waist high, and supported by a strap over the shoulder. The miner breathes the products of respiration into the bag by means of a mouthpiece. This air passes through two tubes containing grains of oxylith, which has the property of retaining moisture and carbonic acid, while setting free a corresponding quantity of oxygen. The vitiated air therefore becomes renewed when stored in the bag.—*Engineering and Mining Journal.*

A WATERPROOF CEMENT.

A water-proof cement that has been patented in Germany consists of vegetable wax and caustic lime in boiling water, which is added to unground portland cement clinker; the whole being then ground together. The inventor makes the claim that a ½-in. coating of this cement placed on a brick wall will render it absolutely water-proof.

A ROCK DRILL SCHOOL.

According to the Transvaal Advertiser, in many trades and professions the apprentice has to pay for his teaching. In marked contrast to this a rock-drill school has been started in the Crown Deep mine (says "S. A. Mine") where thrifty and industrious men may learn the ins and outs of such a remunerative trade as rock drilling, and get paid ten shillings a day while learning. The learners in the "scholar stope" at the Crown Deep are under the supervision of an expert rock-drill miner, and several of the pupils have attained to a degree of proficiency which fits them to fill other and more responsible positions. The mine captain of the Crown Deep is keenly alive to this, and all who become capable workmen will receive capable miners' work at capable miners' pay.

GORDON-HELLMAN ROCK DRILL.

Alfred Lewis, in a recent article in the *London Mining Journal,* states that the Gorden-Hellman rock drill promises to solve the labor difficulty in the Transvaal. It may take the place of the Chinese, reducing the number of stoping boys required from six to one. One boy can do only one hole in a shift by the usual method, while this machine, costing two hundred dollars, with one boy, does from six to nine holes during the same period.

BRITAIN BEMOANS THE LOSS OF MEXICAN TRADE.

In the British consular report, published here, it is stated that there is a great falling off in the trade between Mexico and Great Britain both in quantity and value as compared with that of the United States. The report states that the geographical advantages possessed by the United States offset the great transportation facilities which Great Britain can offer.

COMPRESSED AIR VS. EXHAUST PRESSURE ON MOTOR CARS.

Exhaust pressure is used for a variety of purposes, the chief being to provide the petrol feed from the usual rearwardly-placed fuel tank. In addition to this, in spite of the increasing use of mechanically-operated lubricating devices, many lubrication systems depend upon the pressure of the exhaust gases for their operation. Exhaust gases for these purposes, however, possess certain drawbacks, such as the formation of deposits in pipeways and in the tanks and lubricators themselves, even with the best of filtering devices interposed. The use of some compressed air system would seem, then, to provide the most practicable and altogether satisfactory pressure feed, as it is absolutely free from the disadvantages inherent to the exhaust-pressure system. There is no denying that there is some slight addition to the number of moving parts about the engine, but the mechanism required for the minute air pump that is sufficient to maintain a pressure feed is so insignificant that it need be given no more consideration than the more usual pressure valve. That such a device is an advance on usual practice cannot be denied. It was interesting to note that of the only two chassis so fitted at the recent Olympia Show both were British, one being the Scottish Albion, and the other the English Thornycroft.

DEEPEST CAISSON RECORDS BROKEN.

Part of Foundations for Fulton Street Terminal of McAdoo Tunnel 98 Feet Below Curb.

All records for the depth of foundations in the city of New York were broken recently, when a caisson for the building which is to be over the downtown terminal of the McAdoo tunnels was sunk ninety-eight feet.

The previous record was ninety feet, attained in many of the excavations for the skyscrapers which are under construction in Broadway. The caisson will be filled with concrete and will form the support at Church and Fulton streets for the corner of one of the twin buildings which the tunnel company is erecting.

It will also constitute a part of a great cofferdam which is to surround the station for the electric cars which are to come from New Jersey beneath the Hudson. This cofferdam itself is the largest ever made for a New York office building. It is a solid wall of concrete which rests upon the rock from seventy-five to ninety-eight feet below the curb, and it is ten feet thick.

ALTHOUGH the cost of underground pumping by compressed air may be considerably reduced by the use of reheaters, the conclusion should not be jumped at that is always advisable to install them. In places where the ventilation is poor they are entirely out of the question. It has been observed that the gases of combustion have a deicdedly injurious action on hauling ropes, if allowed to pass up the same shaft, and it is, no doubt, this fact which has prevented more attention being paid to re-heaters. Another point is the fact that most underground air pumps are of small size and a saving of 30 per cent. in operating expenses does not mean much when reduced to dollars and cents.—*Mining Reporter.*

THE new Northern Pacific yards at Laurel, Montanta, will contain a car-cleaning plant with a large air-compressor, capable of cleaning not only passenger cars, but also of cleaning and disinfecting stock cars in accordance with the State law. The plant will have a capacity of 100 stock cars a day, besides all the passenger cars which it will be necessary to clean. In the past the cleaning of stock cars has been done by hand, but this system has been found too slow and expensive.

U. S. PATENTS
ESPECIALLY PREPARED FOR
COMPRESSED AIR

Full specifications regarding any of these patents may be obtained by sending five cents to the Commissioner of Patents, Washington, D. C. (Stamps will not be accepted.)

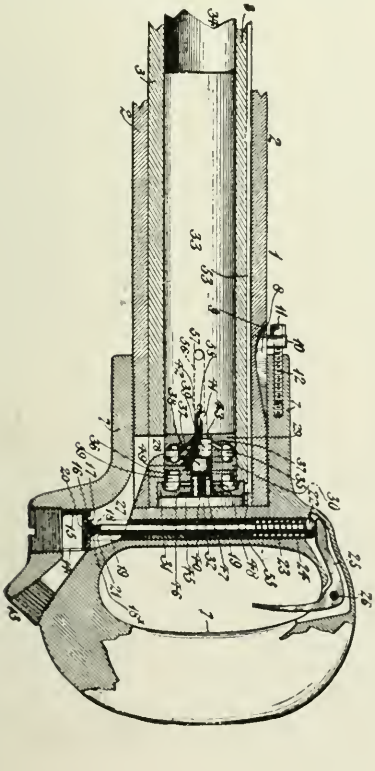
842,324. AIR-GUN. William F. Markham, Plymouth, Mich., assignor to The Markham Air Rifle Company, Plymouth Mich., a Corporation of Michigan. Filed Feb. 23, 1906. Serial No. 302,600.

842,343. AIR-INLET AND BEER-OUTLET BUNG FOR BARELS. Gustave A. W. Schilling and John H. Flach, Denver, Colo., assignors of one-third to Louis Becker, Denver, Colo. Filed Feb. 28, 1906. Serial No. 303,424.

842,352. CARRIER FOR PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed May 17, 1904. Serial No. 208,369.

842,392. EXPLOSIVE-ENGINE. John Eckhard, Buffalo, N. Y., assignor of one-half to Joseph P. Fell, Buffalo, N. Y. Filed June 29, 1905. Serial No. 267,633.

842,626. PNEUMATIC HAMMER. John. F. Clement, Philadelphia, Pa. Filed Apr. 15, 1905. Serial No. 255,800.



Claim.—1. In a pneumatic hammer, a cylinder adapted to be manually held and having a piston therein and a valve mechanism, comprising a main valve, and a plurality of auxiliary valves, the latter being carried by said main valve, said valve moving in substantial alignment with said piston.

12,599. AIR-COMPRESSOR. Ebenezer Hill, South Norwalk, Conn. Filed May 15, 1906. Serial No. 317,004. Original No. 700,927, dated May 27, 1902. (Re-issue.)

842,160. PNEUMATIC-ALVE MECHANISM. Bert Aikman, Chicago, Ill., assignor of one-half to John S. Hamlin, Chicago, Ill. Filed Oct. 21, 1905. Serial No. 283,834.

842,655. PNEUMATIC HAMMER. Martin Hardsogg, Ottumwa, Iowa. Filed July 28, 1904. Serial No. 218,546.

842,774. AIR-BRAKE SYSTEM. William H. Eichelberger, Royalton, Pa., assignor of one-half to Milliard F. Meinsler, Middletown, Pa. Filed Oct. 10, 1905. Serial No. 282,143.

843,522. COMPRESSED-AIR BRAKE FOR GUNS THAT RECOIL ON THEIR CARRIAGES. Joseph A. Deport, Paris, France. Filed Dec. 11, 1906. Serial No. 347,366.

843,481. AUTOMATIC AIR-BRAKE MECHANISM. William McCook, Walton, N. Y. Filed Oct.16, 1905. Serial No. 282,955.

843,180. AIR-WASHER. Charles W. Rogers, Chicago, Ill., assignor to Mathis Brothers Company, a Corporation of Indiana. Filed Oct. 5, 1906. Serial No. 337,525.

842,072. ROCK-DRILL SADDLE. George S. Power Passaic, N. J. Filed Mar. 31, 1906 Serial No. 309,082

842,949. HYDRAULIC PRESS. Berthold Gerdau, Dusseldorf, Germany. Filed Oct. 11, 1899. Serial No. 733,241.

842,923. COMBINED AUTOMATIC AND STRAIGHT-AIR BRAKE. Walter V. Turner, Wilkinsburg, and Edward A. Wright, Edgewood Park, Pa., assignors to The Westinghouse Air-Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed May 6, 1904. Serial No. 206,655.

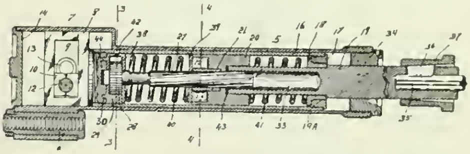
SEVEN—APRIL COMPRESSED AIR

844,410. PNEUMATIC CLEANER. Paul Schauer, Berlin, Germany. Filed May 7, 1906. Serial No. 315,658.

844,466. APPARATUS FOR MOISTENING THE AIR AND DISTRIBUTING WATER AND OTHER FLUIDS. Carl H. Prott, Rheydt, Germany. Filed Sept. 21, 1905. Serial No. 279,459.

844,483. AUTOMATIC AIR-COUPLING DEVICE. William H. Sutherland and Robert N. Van Horne, Sioux City, Iowa. Filed June 16, 1906. Serial No. 322,117.

844,582. ROCK-DRILL. Henry Deitz, Denver, Colo. Filed June 2, 1905. Serial No. 263,366.

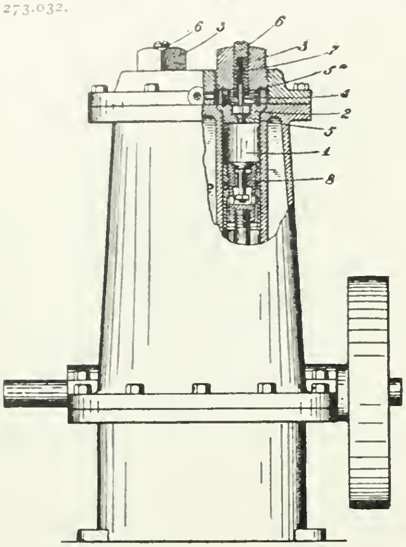


Claim.—In a rock-drell, the combination with a casing, of a reciprocable yoke located therein, a hollow member connected to move with the ykooke, a piston located in the hollow member, a drill-holder connected with the piston, a loose collar surrounding the drill-holder, the latter having a stop to limit the forward movement of the collar thereon, the hollow member also having a stop for the loose collar forward of the latter, a rifle-bar and ratchet carried by the hollow member and connected with the drill-holder for rotating the latter, and a yielding connection between the drill-holder piston and the hollow member, substantially as described.

844,648. AIR-COMPRESSOR. Joseph O. Banning, Zanesville, Ohio. Filed Dec. 18, 1905. Serial No. 292,329.

Claim.—In a fluid-compressor, the combination of a fluid-compressing chamber, a piston therein, and two valves for said chamber one of which is provided with a port and heat to receive the other, independent springs to press on said valves, and two threated nuts one within the other to press, one on one of the springs, and the other on the other of the springs, whereby the pressure of said valves on their seats may be independently regulated.

844,724. AIR-COMPRESSOR. HENRY H. HERRMANN, Chicago, Ill. Filed Aug. 7, 1905. Serial No. 273,032.



Claim.—An air-compressor comprising, in combination, a pressure-storage chamber provided with a valved pressure-inlet opening and a valved pressure-outlet opening, a bellows mounted immediately upon the wall of said chamber to constitute it one of the bellows-walls, said bellows covering said inlet-opening, and being provided with a valved air-inlet opening, a handle-equipped rotatable drive-shaft, a gear loosely mounted thereon and carrying a pallet, a ratchet-wheel on said shaft engaged by said pallet, a fixed gear and a windlass on said shaft, weighted-pulley mechanism having a cable connection with the windlass for operating the drive-shaft, a driven shaft, a fast gear near one of said driven shaft meshing with the loose gear on said drive shaft, a loose gear on said driven shaft carrying a pallet, a ratchet-wheel on the driven shaft engaged by the last-named pallet, a fast year on the opposite end of the driven shaft, a gear operated by said last-named gear and carrying a pitman, and a link connecting said pitman with said bellows, for the purpose set forth.

844,745. SPRAY FOR ROCK-DRILLS. EDWARD G. A. REES-GIBBS, Roodepoort, Transvaal. Filed Sept. 17, 1906. Serial No. 335,023.

844,776. THROTTLE-VALVE AND AIR-STRAINER FOR PNEUMATIC DRILLS. CARL A. CARLSON, Holyoke, Mass. Filed Dec. 7, 1905. Serial No. 290,735.

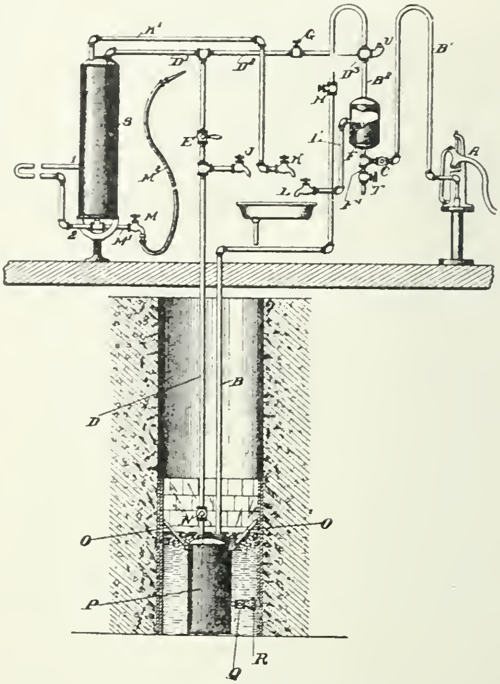
844,801. AIR-COMPRESSOR GOVERNOR. EBENEZER HILL, Norwalk, Conn. Filed Nov. 7, 1905. Serial No. 286,185.

Claim.—The combination with an intake-valve of an air-compressor cylinder, of mechanism adapted to hold said valve open, a speed-governor, and means controlled by the governor and connected with the aforesaid mechanism which when the governor is collapsed causes said mechanism to hold the valve open, substantially as specified.

844,820. METHOD OR FORMING PNEUMATIC TIRES OR TIRE-CASINGS. ARTHUR H. MARKS, Akron, Ohio. Filed Nov. 19, 1906. Serial No. 344,140.

844,870. VALVE FOR PNEUMATIC MUSICAL INSTRUMENTS. EUGENE DE KLEINST, Tonawanda, N. Y. Filed Nov. 27, 1905. Serial No. 289,208.

844,936. PNEUMATIC WATER-LIFT. WILLIAM A. HARRIS and BENJAMIN S. H. HARRIS, Grfeenville, S. C., assignors of four-sixteenths to J. C. Fitzgerald and one-fourth to J. P. Carlisle, Greenville, S. C. Filed June 15, 1906. Serial No. 321,886.



Claim.—The combination substantially as herein described of a supply-tank, a reservoir-tank, a purifier or filter tank, a pipe extending from the supply-tank to the reservoir-tank and having a discharge-faucet, a check-valve between the discharge-faucet and the supply-tank and opening toward the supply-faucet, and a stop-cock between the faucet and the reservoir-tank, a branch pipe leading from the connecting-pipe to the purifier or filter tank and supplied in advance of said filter-tank with an emergency-valve, a coupling and a plug connected with said branch pipe, an air-pipe leading from the filter-tank through the said coupling to the supply-tank and having an intermediate valve, an exhaust-pipe leading from the purifier-tank above the water-level thereof and having a faucet.

WANTED

Position as general sales and distributing agent in Pittsburg district for manufacturer of air compressors, tools and appliances. Long experience in compressed air machinery. At present engaged in engineering and official capacity with large company. Widely known among engineers, manufacturers and purchasing agents. Able man as engineer and executive. Address **K—care of Compressed Air.**

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

MAY, 1907.

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WELL DRILLS FOR BLAST HOLES ON THE PANAMA CANAL.

By DeWitt.

The use of well drills for drilling blast holes was successfully demonstrated by "La Compagnie Universelle du Canal Interoceanique de Panama," generally known as "The Old Panama Canal Company."

During the period from 1880 to 1888 this company employed individual steam-driven well drills, which were mounted on two pairs of railroad trucks, four wheels each, of 1.5-meter (5-feet) gage. These drills used a bit of 12.5-c.m. (5-inch) gage. A number of these dismantled machines are still to be seen on sidings at Empire and Gorgona; no attempt has been made by the Americans to use these drills on account of lack of important parts of both machines and drilling tools.

The actual construction work by the French company was developed by benches of lifts of 5 to 6 meters (16 to 19 feet) vertical height. The American plan of excavation by steam shovels made it advisable to work vertical faces of from 20 to 30 ft., and, as the material to be drilled on the upper level, which is now being removed, is a mixed formation of indurated clay and medium soft basaltic rock, and somewhat difficult to drill with rock drills, it was deemed best after a careful study of the clay and rock formation, and taking into account the depth and diameter of blast holes required for economical work, to use well drills for the purpose. Accordingly in July, 1905, an order was placed for ten drilling machines. These were delivered in November, 1905, by the Star Drilling Machine Company of Akron, Ohio. They were of the pattern known as No. O, or 250-ft. machine, fitted with 5x5-in. reversing engine and using 5⅝-in. diameter bit. They were equipped with the well-known spudding motion and without walking beam. These ten machines were erected and put into service in December, 1905, and have since been giving successful service continuously since that time, and are still in good condition.

At this time, December, 1905, there were about ten steam shovels in active operation on the Culebra Division, and a contemplated increase to fifty shovels within another year made it necessary to adopt a larger system of blast-hole drilling, so in January, 1906, there were purchased from the Austin Manufacturing Company of Harvey, Illinois, twenty of their No. 2 portable well-drilling machines. They are equipped with walking beam motion and have a capacity of 250 feet of 5⅝-in. hole. They have been in constant service.

In January, 1907, orders were placed for forty-five well drills, with 5x5-in. reversing engines, spudding motion, 4-in. diameter bits and capacity of 100 to 150 feet in depth. Forty-three of this lot are now being delivered by the Star Well Drilling Company and two by the Keystone Driller Company of Beaver Falls, Pa. Twelve Star machines and the two Keystone machines have been erected and are in daily service, and at the present writing (May, 1907), there are forty-four well drills in successful operation on the canal work between the locks at Pedro Miguel and the locks and dam at Gatun, the major portion of them, however, being operated between Paraiso and Bas Obispo. In addition to the above well drills there are one hundred and ten (110) 3⅝-in. diameter cylinder rock drills in constant service.

It was early decided on account of the size of the work, to operate all drills, as far as possible, from central power plants, in order to reduce labor and cost of operating a large number of scattered boilers. Prior to October, 1906, all well drills were steam actuated. Since October, 1906, the drills have been run almost exclusively by air, except a few drills in isolated places and on night shifts. (Air compressor plants are not run after 5 o'clock P. M.)

The power is supplied by three compressor plants. No. 1 plant is located at Rio Grande, about one-half a mile south of the town of Culebra, and consists of two Rand Imperial type, 10 duplex steam, compound air compressors, each of 2500 cu. ft. of free air per minute capacity. Steam is furnished by a battery of six old French boilers of approximately 85 h.p. each.

No. 2 plant is located at Empire (three miles from No. 1 plant) and is identical with the first-mentioned plant and in addition has two Laidlaw-Dunn-Gordon duplex steam compound air compressors of a capacity of 2500 cu. ft. of free air per minute, each. At this No. 2 plant the battery of old French boilers

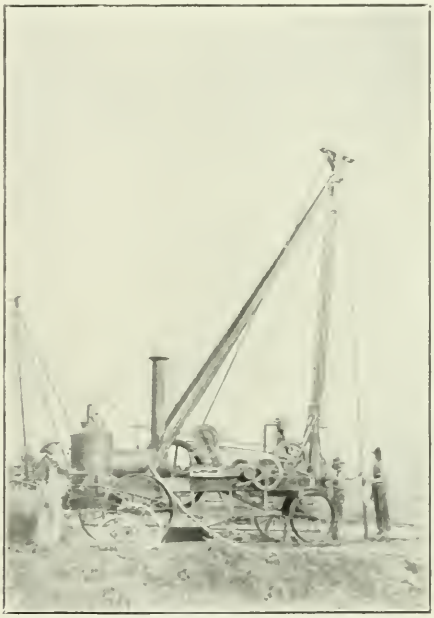
WELL DRILLING MACHINES AT WORK ON THE CULEBRA CUT.

is now being replaced by six Robb-Mumford 200-h.p. tubular boilers.

No. 3 plant, at Las Cascadas (two miles from No. 2 plant), is identical with the enlarged No. 2 plant.

The boiler plants furnish steam at 100 pounds pressure and the average air pressure at the plants is 90 to 100 lbs., the air pressure at the drills varies from 85 to 95 lbs. Drills will not work effectively on less than 75 lbs. air.

STARTING A HOLE.



DRILL IN OPERATION.

The three air plants, above described and having a total capacity when running full load of 25,000 cu. ft. of free air per minute, are connected with each other by a 10-in. wrought iron screw joint main pipe line laid outside the upper slope line and parallel to the center line of the canal. From the No. 1 plant the 10-in. line is extended to Pedro Miguel, one and one-half miles south; and from the No. 3 plant the 10-in. line is extended to Bas Obispo, one and one-half miles north, thus making an immense receiver 10 in. in diameter and eight miles long. At intervals of 1000 ft. along the 10-in. main line, 10x8-in. or 10x6-in. tees, with valves, are placed, a further reduction at the tee to 4 in. is made and a 4-in. line run to the canal prism. From these 4-in. lines a $2\frac{1}{2}$-in. feeder is run inside the slope lines parallel to the center line of the canal and tees are placed at every second joint. From the $2\frac{1}{2}$-in. feeder a $1\frac{1}{2}$-in. or 1-in. branch is laid to the drill, and connection between the drill boiler, which acts as a secondary receiver, and branch pipe is made with a 25-ft. or 50-ft. length of Sprague armored air hose. At times it has been necessary to connect the hose directly with the air chest on the engine, and the result has been satisfactory.

The work of operating each air-driven well drill is done by a runner (who is usually a

West Indian or one of the native mixed Spanish types) and a helper. Drills, when steam-driven, require one runner, one helper and a fireman. Each two machines have one extra helper to look after the pipe line, hose etc. Two nippers are required on every two drills to carry bits to and from the blacksmith shop. Over every three machines is an American foreman and over every nine to twelve machines is an American general foreman.

Drill runners are paid from 25 cents to 38 cents, gold, per hour (nine-hour day). Drill helpers are paid from 16 cents to 25 cents, gold, per hour. American foremen are paid $125, gold, per month. American general foremen are paid from $150 to $175, gold, per month. American blacksmiths and drill sharpeners are paid from $125 to $175, gold, per month. Native drill sharpeners are paid from 50 to 60 cents, silver, per hour (ratio silver to gold 2 to 1). Native helpers receive from 26 to 40 cents, silver, per hour.

On the Empire section, where a larger part of the well drilling work has been done, the character of the material drilled varies greatly; from (1) a mixed clay and soft basalt formation, which material, while classified as soft rock, requires drilling and blasting before it can be handled by a 95-ton steam shovel, to (2) a very hard, fine-grained diabase or basalt, commonly known as trap.

The following figures taken from daily drilling reports show the relative variations in the work done by well drills using a 5⅝-in. diameter bit:—A Star drill working in the softer formation (1) has repeatedly drilled from 75 to 105 ft. of hole per nine-hour shift, while another machine of the same make, working some 800 ft. farther north and on the same level, but in the harder formation (2) has been able to make only 3 ft. per day for five days at a time, changing bits every two hours. These are extreme cases. Taking the average work done during the past seven months, using air as the motive power, the machines have averaged 28 ft. of hole each per nine-hour shift, as against 27 ft. per machine when the drills were steam-driven.

On high points many holes from 60 to 100 ft. in depth have been drilled. The average rate of drilling on these deeper holes has been about 23 ft. per shift. One Star drill at Mount Hope, near Colon, was equipped with a walking beam and has been used continually during the past year for sinking artesian well holes. Several successful holes over 600 ft. in depth have been sunk. Three drills were used at Pedro Miguel and two at Gatun for sinking holes from 70 to 100 ft. deep. These holes were cased and used by the diamond drillers in making tests for lock foundations.

On the ordinary work it has occasionally been found necessary to use casing where the top 6 to 12 ft. was of loose material.

The Star drills are run at an average speed of fifty-five drops per minute, the speed of the Austin drills is about forty-eight drops per minute.

There have fortunately been very few cases of lost tools, the number of accidents of this kind being less than on any similar large work that has come to the writer's knowledge. After extensive experiments with belting, it has been found that a two-ply water-proofed leather belting is the most serviceable and economical for this climate. The best quality hawser-laid manila drilling cable, when in continuous service, has a maximum life of four months.

The general method of drilling and blasting is to drill a single line of well drill holes, spaced 20 to 30 ft. apart and 24 to 32 ft. deep, according to height of shovel cut desired (and calculated to be at the bottom from 2 to 4 ft. below the required grade) and 18 to 24 ft. back from the face of the cut. In the hard rock sections a line of "toe" or "snake" holes 20 ft. deep are drilled with tripod rock drills, to reach a level with the bottom of the vertical holes.

Much of the material is somewhat difficult to blast on account of its tough clay-like character, but it is usually broken to a size which is readily handled by a 5-yard dipper on the 95-ton steam shovels. The larger pieces which cannot be so handled are reduced to suitable size by "mudcapping" or "doby shots." There are numerous hard, massive boulders found throughout the softer formations, which require drilling and blasting. Small air-hammer rock drills have been successfully used on these hard boulders and also in the quarries adjacent to the stone-crushing plants.

All drill holes are "sprung" or "chambered" with 60 to 75 per cent. dynamite, from one to four times, according to the hardness of the material.

It is customary to spring, load and blast a series of five to eight well-drilled holes, with the corresponding toe holes. All firing of blast holes is done with electric batteries. On account of the climate and the perpetual damp condition of the ground, and recognizing the danger of handling black powder in the congested districts, it has been deemed best to discontinue its use.

In February, 1907, with twenty-three working days, there was more than 196,000 lbs. of dynamite and 46,000 lbs. of black powder used along the eight miles of the Culebra Division. During March, 1907, on the same division there were 14,904 linear feet of well-drilled holes put down, at a total cost of $5,557.65, or about 38 cents per foot.

"RAILROAD SANDCRAFT."

The Application of the Sand Blast to Railroad Service.

By J. M. Betton.

STEEL CARS.

The problem of painting the modern steel car has been before the Railway Master Painters since the introduction of this type of car some few years ago, and, with the increased use of steel cars, not only for freight, and with steel passenger cars already in use and bound to increase and in time supersede the present wooden coach, it becomes one of the greatest interest in the railway world.

The steel car is built by contractors controlling large plants especially adapted to this work. The material must be of the best, for the service-abuse of these cars is excessive—the ordinary wooden car would go to pieces under a tithe of it.

CLEANING.

This material to hold the paint, when exposed to the weather, should be cleaned thoroughly and all scale, rust, dirt and grease removed, and for this purpose it is admitted by the Master Car and Locomotive Painters' Association "that an up-to-date sand blast should be installed in the railway car building and repair department, also that its use in contract building shops be enforced."

SPECIFY SAND BLASTING.

Some of the contract building shops are equipped with sand blast outfits and are prepared to use them on their contract work, but the cost of sand blasting a car properly may be several dollars, and if this item is included in their estimate, it amounts to a very considerable sum in a contract for a thousand or more cars, and places the contract shop including it at a disadvantage against another shop which has no sand blast plant, has not figured on sand blasting, and is making a low figure in consequence. This matter settles itself when the railroads call for and insist upon sand blasting in their specifications and contracts, and the difference in expense is more than justified by the increased wear of the paint on such material.

CLEANING LOCOMOTIVE WORK.

In the locomotive paint-shop the sand blast can be applied to removing the old paint from tenders, doing as much work in one day as a dozen men can do with scrapers, stones and old files. Steam domes, sand-box casings, jackets, headlights, cylinder and steam-chest casings, steel cabs, and the like, are also readily cleaned with the sand blast, all old paint, scale, rust and grease being quickly removed, and the clean, gray metal left ready for the new paint.

SPEED.

Records show that the sand blast will clean cars at the rate of one square foot per minute, or, allowing for making ready the machine, refilling the tank with sand, and moving the hose, from 500 to 550 square feet per day of ten hours, and, after repainting, the car should hold its appearance and be free from rust for about five years, because the paint is applied to the clean surface, and there is no scale to flake off; nor rust, nor dirt, nor grease to prevent its adhering to the clean metal. Benzine, which is dangerous to use in the shop, scrapers and wire brushes, will not remove the obstructing elements in either the time or perfection of a sand blast, which is conceded as by far the best method of preparing new mêtal for painting, as it is also for removing the old paint and accumulations.

REMOVE RUST.

Rust goes on all the time until it is all removed or the material all gone, and paint applied over it cannot be depended upon while any traces of it exist. The sand blast searches the metal for rust as with a microscope and removes it thoroughly, while the best and most conscientious car painter can only get off slowly and incompletely with scraper, emery paper or coke rubbing this bane of the foreman car and locomotive painter.

QUALITIES OF SAND BLAST.

A sand blast to do this work must be well made, to stand the hard usage to which it is subjected. It must be easily filled, preferably with a shovel, and must be sufficiently portable to enable it to be moved about the work when required. It must give a sharp, strong and well-distributed blast, the sand and air being most intimately mixed, so that every grain of sand makes its record on the work, without undue scattering or waste. It must further be designed with some consideration for the cost of operation, and use the least possible air and sand.

Any sand blast will work if there is air enough behind it. On the shores of Cape Cod are many evidences of the sand's work on buildings, with glass dimmed and worn shingles or clapboards cut through, all indicating the cutting powers of this agent when backed by the uncontrolled force of the mighty winter winds, unlimited in quantity and untrammeled by man's devices.

COMPRESSED AIR.

In the modern manufacturing works the main object is to chain the forces of nature: steam, electricity and air, and to obtain from them the utmost benefit at the minimum of cost.

It is not so many years ago that air has been compressed and used again in mechanical processes, and, having been found a willing, convenient and valuable agent, its use has spread from one department of the works to another, each demanding a little more, until the capacity of the air compressor is soon reached. The sand blast is one of the applications of compressed air, and the Injector Sand Blast has been designed to fulfill the conditions above specified, and especially those of economy of air and sand.

THE INJECTOR SAND BLAST.

Sand blasts, as usually made, project the sand by one application of the air, a few with two, but in the Injector Sand Blast the air supply is subdivided into three parts, or jets, one of which in the center of the sand valve, creates a difference in pressure between that in the sand tank and in the upper part of the mixing chamber equivalent to that of a slight vacuum, causing the sand to flow with greater regularity, and it also scatters and mixes the falling sand.

The second, or mixer jet, acts on the flowing sand and mixes it more thoroughly, the flow of the sand being retarded by the peculiar construction of the mixing chamber.

The third, or forcer jet, conveys a further supply of air to this mixture of air and sand and sends it from the machine, through a carefully graduated orifice, to the delivery hose, terminating in a special nozzle of smaller diameter than the hose, which, by again retarding the current, adds to its velocity and force, the mixture, now at the maximum density of the air, striking the work with the greatest vigor and force, each particle of sand and air being utilized.

THREE-WAY COCK AND SAND VALVE.

The three air jets are controlled by one three-way cock and the flow of sand is regulated by raising or lowering the sand valve. Its operation is simple and easily controlled, and the machine can be operated by ordinary labor.

AIR PRESSURE.

For cleaning steel cars and locomotive work an air pressure of 30 pounds is recommended, the air and sand being distributed through a one-half-inch nozzle. When working under these conditions the sand blast will require 161 cubic feet of free air per minute, and this pressure, to give the best results, should be steady. If the air supply is taken from a main from which other supplies are taken, and the pressure is liable to fluctuate, a small receiver, about 18 inches by 30 inches, introduced in the air supply to the sand blast will not only give a steady pressure, but will catch any condensation from the air, which can be drawn off from time to time.

DRY AIR.

The air in the sand blast must be dry, otherwise the condensation from the sides of the tank will gradually percolate through the sand about the sand valve and cause it to cake and arch, stopping its flow. If this occurs, remove the sand from the tank and start over again with a new filling of dry sand, and remove the condensation by tapping the low point in the main air pipe, or pipe an "U," with a drip cock near the sand blast.

SAND.

Use good, clean, sharp sand, screened to remove material that would clog the sand valve or nozzle, and grade the sand to the work. All sand should be dried by heat over a slow fire, care being taken not to burn it. If dried too quickly, or with too hot a fire, the sand will calcine and powder when it strikes the work. Allow the sand to cool for several hours before using. A hot sand creates steam in the sand tank, which will condense on the sides and cause delay.

Time the filling of the sand tank so that at the end of the day's work it may be left empty, as the sand will absorb moisture and may require to be removed in the morning.

AIR PIPING.

The air supply may be brought from any convenient distance, but the diameter of the pipe should increase from that of the connection to the sand blast, to allow for loss of pressure from friction, and in no case should the air connection be of smaller diameter than the connection to the sand blast.

HOSE.

The sand delivery hose may be of any convenient length and preferably of not too large diameter. With a medium size of hose the current of mixed sand and air is maintained at its maximum velocity through the full area of the hose, while in a large hose the maximum velocity is in the center, and in long lengths the sand will drop out of the current and fall to the bottom of the hose, especially if there are any pockets, this showing in the undue discharge of sand at times, until the hose is clear, when the normal flow is resumed.

PROTECTION.

The operators may protect their eyes and faces by helmets, masks of wire, goggles or veils, and, if the dust is excessive, an exhaust fan arranged to take the suction from the floor level of the sand blast room will be found very effective.

CLEANING BRIDGES AND STEEL WORK.

Outside of the shops and along the line the sand blast becomes an efficient means of cleaning old paint, rust, scale, and dirt from the steel structural work of bridges, viaducts, tunnels, and other structures.

The records of the sand blasting of steel structures in the United States are not numerous, and are summed up to the year 1903 in a paper on "Sand Blast Cleaning of Structural Steel," by George W. Lilly, Associate Member American Society Civil Engineers, printed in the Transactions of that Society, from which the following extract and notes are made:

ADVANTAGES OF SAND BLASTING.

"The greatest merit of the sand blast is that it removes from the surface of the metal every trace of dirt, scale, rust and grease, and the bright metallic surface is everywhere exposed and perfectly cleaned. This is an ideal condition to secure the strong adhesion of the paint, so that, as far as it is possible, it will protect the metal. The thoroughness of the cleaning effected by the sand blast is noted especially upon metal surfaces which have been pitted by rust and corrosion to a considerable degree. The pits are cleaned as thoroughly as other places. It also reaches and cleans effectually every portion in reentrant angles and on the edges of the different sections of a beam, girder, or post, on and around rivet heads, and in many other places either entirely inaccesible to the wire brush or steel scraper, or in which they are used with great difficulty and little effect. Such places cannot be cleaned thoroughly by hand, even with the most diligent effort. Even plane surfaces of considerable area on old structures requiring repainting, especially where covered largely with scale and rust, cannot be thus cleaned so as to remove all the dirt, rust, scale and disintegrating paint. There will still remain sufficient rust and scale to separate slightly the paint from the metal, so that there is not the intimate contact and firm adhesion necessary to prevent the rusting process. The continuity of the coat of paint will soon be broken at places, and moisture and gases in the atmosphere coming in contact with the metal, rust will be formed even under places where the paint remains intact.

"Paint applied to such surfaces can often be stripped off like the peel of an orange, and still remains tough and elastic."

The steel for the anchorages of the cables of the new East River bridge in New York was cleaned by the sand blast, as was also some of the steel in the Boston Subways. The bottom of U. S. S. "Atlanta" and some new plates for U. S. S. "Massachusetts" were cleaned in 1897 at the Brooklyn Navy Yard. The 155th Street viaduct in New York City, containing 600,000 square feet of painting surface, was also cleaned in the same year by the sand blast. In 1898 and 1899 the iron lock-gates and a portion of the aqueduct of the Muscle Shoals Canal were cleaned by sand blasting. The Pittsburg, Cincinnati, Chicago and St. Louis Railway Company used the sand blast in 1899 in Columbus, Ohio, and at Akron, Ohio. The City of Columbus, Ohio, in 1901 and 1902, used the sand blast in cleaning viaducts in the vicinity of the Union Station, which had rapidly deteriorated from rust and the chemical action of the steam and gases from locomotives.

135,500 square feet of surface were cleaned under an average pressure of 35 pounds of air, with ½-inch nozzles and Lake Erie sand, at an average cost of about 3 cents per square foot, including the cost of labor, flagmen, air (which was paid for at the rate of 60 cents per hour for two machines in operation), sand, and drying, the average number of square feet cleaned per hour by one sand blast being 54. On this work it was found that a pressure of about 25 pounds of air did very efficient work where only light scale, rust spots and disintegrating paint were to be cleaned off.

The surface of the steel cleaned had about the appearance of frosted silver, and the paint covered thoroughly all portions, whether pitted or not.

The cleaning outfit was limited to two machines by the small capacity of the air compressor, and the conclusions deducted were that for ordinary cleaning of bridge and other structures, not subjected, as viaducts, to the blast and gases from locomotives, sand blast cleaning can be done at from 1¼ to 2 cents per square foot, a more perfect equipment being used.

CLEANING BRIDGES.

The Boston and Maine Railroad has used a portable sand blast outfit for cleaning bridges, under an air pressure of from 15 to 18 pounds, which was found very effective on weather rust not heavily scaled, with fine sand, coarse sand being used where the metal was pitted and the surface hard to get at. Three sand blasts were operated from a gasoline engine by a foreman and six men, three on the nozzles and three drying sand and refilling the machines.

NEW YORK SUBWAY.

The contractors of the Rapid Transit Subway in New York City used the sand blast for cleaning steel columns and girders of standard size and design, which had been delivered and piled exposed to the weather from eighteen months to two years, and on which, when ready to use, it was found that the paint had worn off considerably and a part of the steel was corroded. The air pressure was 65 pounds, the nozzle ½ inch, and the work was done by a foreman, two nozzle men, two sand men, and one laborer to assist the nozzle men in handling the hose. The plant was stationary and the steel was brought to it by a traveling crane.

In some of the instances mentioned the work was done under conditions more or less crude, and it is apparent that better results could have been obtained at less cost had the working outfits been better proportioned to the work.

SAND BLAST OUTFIT.

The sand blast outfit for cleaning structural steel work on railways should include two or more sand blasts, size 24 inches by 24 inches, an air compressor driven by a gasoline engine, an air receiver of ample size, a gasoline tank, the necessary air hose, delivery hose, nozzles, helmets, wrenches, spanners, a set of machinist's tools, including a set of pipe dies and stock, pipe vise, a number of lengths of iron piping of various sizes for leaders, a selected lot of pipe fittings, a sand drier and screens, ladders, ropes and tackle, and a swinging painters' stage.

SPECIAL CAR.

This outfit may be installed on a flat or derrick car and covered with a housing, but as the opportunities for operating it from the car must be limited, all should be readily removable and capable of being erected on the ground convenient to the work.

SETTING UP.

The engine and the compressor are set up, the air receiver connected, and from this the air line is led to and across the structure to be sand blasted. The air piping should be of as large area as is necessary to deliver the air at the farthest point without loss from friction. It should have reducing tees piped in about every fifty feet, from which the delivery to the sand blasts can be taken, as these machines are moved along the work, and if there is condensation in the piping it can be largely removed from one of these outlets between the air receiver and the sand blast.

The sand blasts can be set on the ground beneath the structure, on the structure itself, or suspended on staging; but it will be found more convenient to keep them on the ground on account of greater ease in filling, and the current of sand and air is as readily delivered above the sand tanks as below, the pressure being increased according to the height.

SAND DRIER.

The sand drier may be of hopper or cylindrical pattern encircling a common stove, or a flat pan, the first being preferable, as the sand falls when dried through holes left in the bottom of the hopper, and does not require hand tending to prevent burning, as with horizontal driers.

AIR COMPRESSOR.

The air compressor, of compact, strong and durable design, either single or duplex, and of any of the well-known makes, should be capable of compressing to a maximum pressure of 50 pounds per square inch 500 cubic feet of free air per minute, assuming that two sand blasts, each having a half-inch nozzle, are operated simultaneously, this pressure being sufficient to deliver the blast to a height of 150 feet above the sand tank.

PRESSURE.

For ordinary work and heights a pressure of 30 to 35 pounds will be ample and will remove all scale, rust, old paint, and dirt. The required amount of compressed air for different nozzles and pressures can be found in table on second page of cover.

ENGINE.

A gasoline or other engine is belted or otherwise connected to the compressor and may be of any of the commercial types readily found in the open market, of not less than 70 H. P. It is no economy to cut down either in the size of the engine or compressor, and the advantage of a surplus of either air or power may at times offset the slightly increased cost of a plant that can be called upon in case of need and be not found wanting.

AIR RECEIVER.

The air receiver should be steel, tested to at least 120 pounds air pressure, in dimensions about 30 inches to 60 inches, provided with drain cock, safety valve, pressure gauge, and, for railway work should have an especially large air outlet, at least 3 inches, to give an ample volume of air in the air pipe without reduction of area if needed for a long line, the outlet being pushed down for ordinary work.

SUPPLEMENTARY AIR RECEIVER.

On a long line of air piping a supplementary air receiver about 18 inches by 30 inches or 36 inches will aid materially in maintaining a steady volume of dry air.

LABOR.

This plant will require two nozzle men, one engine man, and two laborers drying sand and filling the sand tanks, and one foreman to regulate the flow of sand and generally oversee the whole work.

SUMMARY.

The foregoing describes briefly a sand blast outfit adapted to railroad work, which will clean any structural steel *thoroughly*, remove all rust, and leave the gray metal ready for the painter's gang to put on the protecting coat of paint.

THAT compressed air is regarded seriously by automobile manufacturers is shown by the system introduced by the Lozier people. The air is automatically compressed, and when required for the different purposes is supplied to the various systems. The automatic compressor operates from the exhaust of the engine through a pressure regulator, and the pressure may be controlled and maintained at any desired point up to eight pounds, indicated on a small air gauge on the dash.

One of the functions of air pressure is to drive the gasoline to the carburetor from the 27-gallon gasoline tank suspended from the rear of the chassis. The second use of the compressed air is to force lubricating oil from a 3-gallon tank suspended beneath the chassis to the dashboard oiler, obviating the necessity of frequently refilling the dash oiler with an oil can and funnel. When the supply in the dashboard oil reservoir is low, it is only necessary to open a cock, allowing the air to enter the main reservoir, and the oil is forced to the dash oiler.

The third use of the compressed air is to drive water from a special water reservoir to the water packets of the running brakes. This system is only used in hilly country or in touring abroad among the Alps and through mountainous regions. The system can be cut off by a special air cock until required, when by admitting the pressure to the water-brake system each application of the brake pedal causes a flow of water to the brake drums.

THE FLOW OF AIR IN LONG TUBES, WITH SPECIAL REFERENCE TO PNEUMATIC DISPATCH.

By B. C. Batcheller.

PART II.

Relative Economy of Compression and Exhaustion.

The economic advantages of operating a pneumatic tube by exhaustion over compression have been mentioned. It can be further illustrated by comparing one of the pressure curves of Fig. 6 with a similar vacuum curve that gives the same mean velocity. This has been done in Fig. 8. Curve A shows the initial pressures required to give a mean velocity of thirty miles an hour in 8-in. tubes of different lengths. The pressures are measured in pounds per square inch above atmospheric. Curve B shows the vacuum in pounds per square inch below atmospheric required to give the same mean velocity in the same tube. Curve A is the same as curve B, Fig. 6, drawn to a larger scale. The curves have been plotted from the following table and the table was computed by formula (18).

Mean Velocity, 44 feet per second.

Compression		Exhaustion.	
Gauge Pressure, Pounds per sq. in.	Length of Tube. Feet.	Gauge Pressure. Pounds per sq. in,	Length of Tube. Feet
2.01	5,000	− 2.	5,701
2.90	7,000	− 4.	12,142
4.35	10,000	− 6.	19,245
5.42	12,000	− 8.	26,751
6.87	14,500	−10.	34,096
7.18	15,000	−12.	40,274
10.50	19,707	−14.7	44,090
23.	30,377		

It will be seen that 10½ lbs. pressure will maintain a mean velocity of 44 ft. per second in a tube only 19,707 ft. long, while 10 lbs. vacuum will give the same velocity in a tube 34,096 ft. long.

The vacuum curve has a double curvature and is more nearly a straight line than the compression curve until it approaches the limit of a perfect vacuum, where it turns sharply upward and becomes vertical at the limit. The vacuum curve meets the asymtote of the compression curve at a perfect vacuum, or —14.7 lbs. In other words, if the law held to the limit, an infinite initial pressure would give the same mean velocity as a perfect vacuum.

The best measure of the relative economy of compression and vacuum methods of working is by comparison of the horse-power required to compress and exhaust the air to obtain the same mean velocities. For example, assume, as before, an 8-in. tube and a mean velocity of 44 ft. per second; the following table gives the theoretical horse-power for tubes of various lengths operated by the two methods. The horse-powers were computed by formula (25). The results are plotted in curves A for compression and B for exhaustion, Fig. 9:

8-inch Tube. Mean Velocity, 44 feet per second.

Compression		Exhaustion.	
Length of Tube. Feet.	Horse-power.	Length of Tube, Feet.	Horse-power.
2,500	3.93	5,701	7.89
5,000	8.24	12,142	15.59
7,000	12.01	19,245	23.35
10,000	18.35	26,751	31.57
12,000	23.13	34,096	41.14
15,000	31.35	40,274	54.21
19,707	47.78	42,975	67.59
30,377	121.17	44,090	135.60

Thus, it will be seen that the advantage on the side of vacuum working is considerable. A tube 20,000 ft. long, or a little less than four miles, requires double the power to operate by compression than it does by exhaustion. The reason for this difference is to be found in the fact that the friction of the air increases with its density. By rarifying the air, the friction is reduced and consequently the power expended at the pump.

The vacuum horse-power curve B rises abruptly as the limit of a perfect vacuum is approached, but this part of the curve is beyond the limit of practical operation, so need not be considered. Up to lengths of 37,000 ft. the curve is nearly a straight line, which shows that the power required in vacuum working is nearly proportional to the length of the tube. This is far from true of compression.

PRACTICAL APPLICATION OF THE FORMULÆ.

In the foregoing formulæ we have a statement of the relations between the pressure, velocity, power and dimensions of the tube for a constantly flowing current of air when the tube is straight, smooth and uniform in cross-section, with nothing to obstruct the free flow of air. No allowance has been made for the effect of the carriers, the retardation of bends and other disturbing elements, which in a practical system must be taken into consideration. These secondary, but none the less important. factors are irregular and some of them constantly changing, as, for example, the relative velocity of the carriers and the air current. They can be determined only by experiment and are usually expressed by emperical formulæ or co-efficients.

Carrier Velocity.—Pneumatic dispatch tubes may be operated in two ways: The initial pressure or vacuum may be maintained constant. in which case the speed of the air and the carriers will vary with the number of carriers in the tube at any given time; or the weight of air flowing per unit of time may be kept constant, resulting in fluctuations of initial pressure or vacuum, according to the number of carriers in the tube. The first may be termed a constant-pressure method; the second. a constant-velocity method—although the mean velocity of the air is not quite constant and independent of the number of carriers in the tube. but so nearly so that it may be considered constant for all practical purposes.

The constant-pressure method is used when several tubes are operated from a common reservoir, as, for example, the cash-carrying systems in stores, and the London telegraph system. The disadvantage of this method lies in the fact that the work done is not proportional to the load, the more carriers that are placed in the tube the slower they move until the number becomes so great that the tube is stalled. If two or more tubes are drawing their power from a common reservoir, the heaviest loaded tube takes the least powre, while the reverse should be the case. On the other hand, with the constant-velocity method the power required fluctuates with the load; as the number of carriers are increased the pressure or vacuum increases accordingly. If using vacuum the tube may be stalled when the force necessary to move the carriers exceeds a perfect vacuum, but with pressure above the atmosphere there is no limit so long as there is sufficient power available. It is usually desirable to have the speed of the carriers as uniform as possible, independent of the number in the tube. If the friction of the carriers is considerable, there may be some variation in the final velocity with which they arrive at the end of a long tube, and this variation increases with the diameter of the tube, because the pressure required to move the carriers bears a greater ratio to the pressure required to move the long column of air. Suppose that a large number of carriers are moving in a tube at a given time under 10 seconds' headway, and that suddenly no more carriers are dispatched; the presence of these carriers has caused the initial pressure to rise several ounces or pounds under the constant-velocity method of operating; as the carriers arrive at the end of the tube, the load is reduced and the air in the tube expands, causing the later carriers to travel toward the end of their journey with a greater velocity than the first. The reverse effect takes place when a large number of carriers are dispatched in a tube in which none were traveling.

In practice the carrier never has the same velocity as the air current that propels it, unless it is provided with a packing that fits the tube very closely. and that is seldom the case. Usually the diameter of the carrier is somewhat less than that of the tube. which leaves a space through which the air can pass, and the velocity of the carrier is reduced below that of the air in proportion to the amount of air that escapes past it.

If u equals the velocity of the air current at the carrier. u_c the velocity of the carrier, and d the co-efficient of slip. then

$$d = \frac{u_c}{u}$$

Or,

$$u_c = du$$

Carriers are sometimes provided with expanding packing that prevents any escape of air, in which case d equals unity, but usually d is less than unity. and as the carrier wears its value becomes less. To be accurate, values of d must be determined by experiment. The following are the results of several experiments:

Experiment One.

Smooth brass tube, inside diameter...	2.180 in.
Carrier, brass with felt heads, diam...	2.000 in.
Difference	0.180 in.

Vacuum = 0.75 lbs. approximate: weight of carrier = 0.406 lbs.; d = 0.60.

Experiment Two.

Smooth brass tube, inside diameter . . . 2.055 in.
Carrier, brass, with felt heads, diam . . . 2.000 in.

Difference . . . . .055 in.

Vacuum = 0.75 lbs. approximate; weight of carrier = 0.406 lbs.; d = 0.92.

Experiment Three.

Bored cast iron tube, inside diam . . . . 6.125 in.
Carrier, with bearing rings compressed cotton and rubber, diam . . . . 5.984 in.

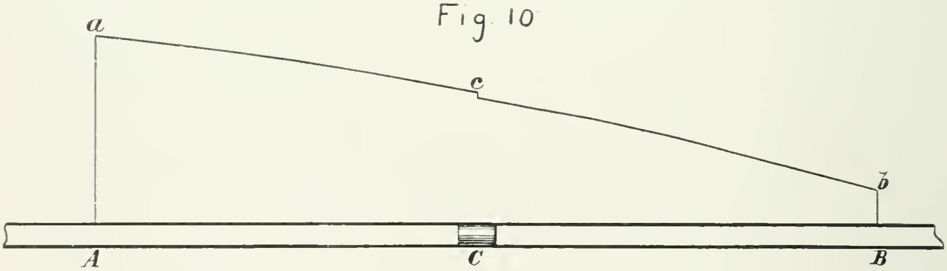
Difference . . . . 0.141 in.

$p_1 = 19.89$ lbs. absolute; $p_2 = 17.52$ lbs. absolute; L = 2992 ft.; weight of carrier = 8.344 lbs.; d = 0.94.

Experiment Four.

Tube and carrier same as Experiment Three. $p_1 = 17.44$ lbs. absolute; $p_2 = 15.13$ lbs. absolute; d = 0.92.

Fig. 10



In the absence of experiments, the value of L can be roughly computed from formula for the flow of air through an orifice, considering the opening between the tube and carrier as an orifice. The difference in pressure in front and in rear of the carrier can be computed from (33).

Carrier Resistance.—The data usually given upon which to construct a system of dispatch tubes is the dimensions of the tube and the mean velocity of the carriers, from which must be computed the pressure, the quantity of air, the horse-power and such other information as may be required.

From the mean velocity of the carrier and the value of L the mean velocity of the air, u_m, is obtained by (32). Then substituting u_m in (18) and solving for the initial pressure, p_1 (or final pressure, p_2, in case of vacuum working), we have the pressure necessary to maintain the flow of air with no carriers in the tube.

In Fig. 10 let AB represent a tube in which a constant current of air is flowing from A towards B, with a carrier in the tube at C. The pressure is represented by the curve *ab*, which steps down abruptly at *c*, on account of the friction of the carrier.

Let w = the weight of the carrier.
β = the co-efficient of friction of the carrier.
A = the transverse sectional area of the tube;

Then the air pressure per square inch necessary to keep the carrier moving with uniform speed is—

$$p_c = \frac{\beta w}{A}$$

This is the height of the step at *c* in the curve. The pressure p_c is the difference in pressure in front and in rear of the carrier. If there are to be n carriers in the tube at the same time, then the pressure necessary to keep all the carriers in motion will be

$$np_c = \frac{n\beta w}{A}$$

This must be added to the initial pressure,

p_1 (or subtracted from p_2, in case of vacuum), which is necessary to give the required air velocity when there are no carriers in the tube.

For carriers with felt heads sliding in a smooth brass tube ,such as used in cash-carrier systems,

$$\beta = 0.48$$

For a light leather carrier in a smooth brass tube

$$B = 0.39$$

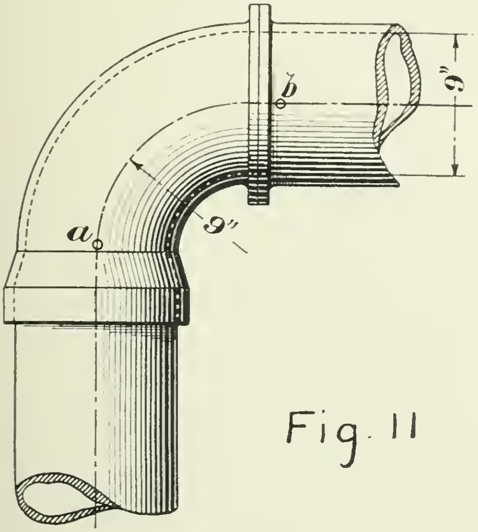


Fig. 11

For a 6-in. or 8-in. carrier, with bearing rings of compressed cotton and rubber sliding in a bored cast iron tube

$$B = 0.40$$

Resistance of Irregular Conduits.—Changes in the direction or velocity of the air current causes resistance to the flow, which is usually expressed by a loss of pressure. The curves in the tube through which the carriers pass are usually of such a long radius that they can be considered as straight tube, but there are often short elbows and branches in supply pipes leading from the air compressor to the tube, which must be considered, and the air has frequently to flow through lantern openings in entering and leaving the tube, that offer considerable resistance. If the supply pipe is long, its resistance can be computed by the same formula used for the tube. The additional resistance of each elbow and lantern opening can be estimated separately. For example, the pressure on each side of a 90° elbow of a 9-in. pipe, in which the mean radius of curvature is 9 in., was found to be 11 in. and 11.0184 in. of mercury, respectively, when the velocity of the air was about 45 ft. per second.

The elbow is shown in Fig. 11. *a* and *b* are the points where the pressure was measured. Another example gives the loss of pressure due to the resistanc of lantern openings in a 6-in. tube. The pressure at *a*, Fig. 12, was 0.49 lbs. per square inch and at *b* 0.34 lbs. The velocity of the air was 60 ft. per second. The cross-section of the air passage was at every point at least equal to that of the tube.

The resistance of the pipes, including elbows, tees, lantern castings, etc., that convey the air from the compressor to the tube or from the tube to the compressor expressed in loss of pressure should be added to the initial pressure of the tube proper, or, in case of vacuum, subtracted from the final pressure, and it should not exceed 10 per cent. of the loss of pressure in the tube. This should also include the resistance of passages from the tube to the atmosphere.

Quantity of Air.—The volume of air in cubic feet at atmospheric pressure that will flow per second is computed by multiplying the velocity of the air at the open end of the tube by the cross-sectional area of the tube, the velocity having been computed by formulæ (13) and (19). If air is taken from the tube for any purpose, such as the operation of

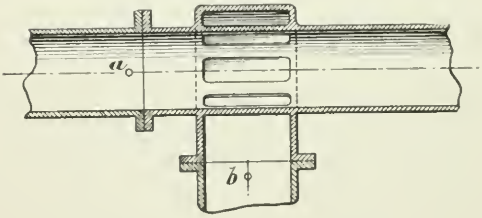


Fig. 12

dispatching or receiving apparatus, or, if there is any escape at other points than the end of the tube, allowance should be made for this.

Power.—Having computed the initial pressure or vacuum at the compressor and the quantity of air required, it becomes a simple matter to compute the horse-power by use of formula (26), making proper allowance for the efficiency of the compressor.

Referring to formula (33), if βw is the force required to keep a carrier moving, the horse-power required to move it with a velocity of u feet per second is

$$\frac{\beta w u}{550}$$

and for n carriers

$$\frac{n \beta w u}{550}$$

which is the power absorbed by the friction of the carriers.

INTERMITTENT AIR CURRENT.

In all that has been said thus far in regard to the laws of the flow of air in long tubes, a constantly flowing current has been assumed. Dispatch tubes are, however, frequently operated by an intermittent current—*i. e.*, a carrier is placed in the tube, the air is turned on from a reservoir and turned off again when the carrier arrives at its destination. The foregoing formulæ do not apply to air flowing under these variable conditions; in fact, no rational formulæ have been constructed for a variable flow. When a valve is opened and air is allowed to flow into a long tube, work is done in overcoming the friction of the inflowing air against the walls of the tubes, in accelerating the air in the tube, in compressing or exhausting the air in the tube, and in overcoming friction of the air in the tube. Finally a state of constant flow will be reached if the supply is kept up for a sufficient length of time; then when the supply is shut off the current gradually ceases until the air in the tube comes to rest. It is hardly possible to construct a formula for mean velocity under such conditions. In starting the air current in an 8-in. tube four miles long some minutes elapse before the constant state is reached.

When a valve is opened between a tube and a reservoir containing air under pressure a pressure gauge attached to the tube shows a lower pressure at first than it does after a minute or two has elapsed, when the constant rate of flow is established. The same is true when the reservoir is exhausted.

The following table gives some observations on this point with a 2¼-in. tube 5523 ft. long. The pressures are in inches of mercury:

The time of transit of a carrier through a tube is less when the tube is worked intermittently than when it is worked continuously, if pressure above the atmosphere is used, but when vacuum is used, the time of transit is greater when the tube is worked intermittently than when worked continuously. The reason is this: The mean velocity of the air depends upon its density. When pressure above the atmosphere is used, the mean density of the air is less during the period of variable flow than after it has reached the constant state; on the other hand, with vacuum the mean density is greater during the variable period. The higher the effective pressure employed, the greater is the difference in speed. With 6 lbs.

Time after Opening Valve.	PRESSURE				VACUUM						
	1	2	3	4	1	2	3	4	5	6	7
15″	14 5	13.7	11.5	12.4	9.5	9.0	11.0	10.5	9.7	9 6	9.0
30″	16.5	14.7	12.7	13.0			11.5	11.7	4.5	11.5	9.2
45″	17 0	15.0	13.	13.2			11.7	12.0	12.0	11.9	
60″		15.2				9.6	12.0			12.1	
75″		15.7			9.7	9.7					
90″		16.2									9.5
105″		16.5						12.2	12.2	12.2	9.7
120″		16.7	13.2								
135″		17.2									10.0
150″	17.2					10.2					
165″							12.2				

effective pressure, for example, a carrier takes only 3 per cent. longer time with continuous than with intermittent working, whereas, with 14 lbs. effective pressure it takes nearly 6 per cent. longer time.

The following table gives the percentage of time that would be lost in transit by using the continuous instead of intermittent method of working:

Effective Pressure per square in.	Extra transit time beyond that occupied with Intermittent method. Per Cent.
6	3.1
7	3.6
8	3.9
9	4.2
10	4.5
11	4.7
12	5.0
13	5.4
14	5.7

Percentage of time gained by vacuum working with the continuous method:

Effective Vacuum per sq in.	Time saved; per cent.
3	1.9
4	2.6
5	3.4
6	5.3
7	4.9
8	5.8

The relative advantages of the two methods of working a tube continuously or intermittently usually depend upon the economy of power and the capacity of the tube system to transport material. When only a few carriers are dispatched, and those at long and irregular intervals, the intermittent method saves a great deal of power; on the other hand, if a large number of carriers are to be dispatched during a long period of time the advantages lie with the continuous method. The intermittent method permits of reversing the air current and using one tube for dispatching in both directions.

Condensation of Moisture in the Tubes.

More or less moisture is precipitated in tubes laid underground, owing to the fact that the earth is usually lower in temperature than the atmosphere. It has been observed that the higher the pressure used the greater is the condensation, so that for long tubes requiring considerable pressure it sometimes becomes very troublesome. Most of the moisture is precipitated near the end of the tube where the air enters; therefore "drips" should be placed at frequent intervals in this part of the tube.

Take an example: Suppose the temperature of the atmosphere is 75° Fahr., and that the relative humidity is 80, a cubic foot of air then contains 0.00107 lbs. of water vapor. Now suppose the air enters a tube and is cooled to the temperature of the earth, say, 60°. At this temperature a cubic foot of air can contain only 0.00082 lbs. of water vapor; therefore the difference between 0.00107 and 0.00082 is 0.00025 lbs. from each cubic foot of air will be precipitated on to the walls of the tube.

There is seldom much trouble from this source in the cold weather, but in the latter part of summer the tubes are sometimes very wet, so that the water gets into the carriers if they do not close tightly. The difficulty can be partly remedied where double tubes are used for dispatching in opposite directions by causing the air from one tube to return by the other and so avoid drawing fresh air from the atmosphere.

(*To be continued.*)

TECHNICAL PUBLICITY ASSOCIATION.

The subject of "house organs" for manufacturing concerns was discussed at the regular monthly meeting and dinner of the Technical Publicity Association, held Thursday evening, March 28. Addresses were made by Stuart Benson, R. Wallace & Sons Mfg. Co.; David Gibson, Globe Machine and Stamping Co.; Henry M. Cleaver, Niles-Bement-Pond Co.; H. L. Myers, New York Leather Belting Co., and W. G. Snow, Meriden Britannia Co. Each one of the speakers is the editor of a successful publication published in the interests of the company he represents. In some cases the house organ has taken the place of advertising in the trade press; and in other cases space in the trade magazines has been used as before or merely to exploit the "house organ."

THE DEVELOPMENT OF THE HAMMER DRILL.*

By H. L. Sinclair.

No doubt those who are interested in mining or the improvements in mining machinery are aware that during the past three years many changes are noticeable in the methods used in breaking ground. Since the introduction of the first piston drills, many years ago, improvements have of course been made from time to time, but the general construction has been the same. While admitting that the cost per foot broken was, in many cases, higher than with hand drilling, operators have continued using the larger 3-in. to 3¼-in. machines in their crosscuts and shafts, and 2½-in. to 2¾-in. machines in their drifts, raises and stopes. At the same time there have been many complaints made against the operating and maintenance expenses.

Fuel costs in most mining camps were high and there was very little ground in a crosscut or a shaft which could be broken and mucked for less than $10 per foot. It was necessary to have a drill runner and helper for each machine, or, where two drills were worked in the same heading, two drill runners and a helper. The runners were supposed to be experienced men, both in the art of breaking ground and in keeping their drills in good running order, and were entitled to at least $4 for an 8-hour shift. In drift and crosscut work it was necessary to either work but one drill shift or handle part of the muck twice in order to give the runners a "set up." For these reasons it was no wonder that the costs of breaking ground ran into money, and the operators were at their wits' end to find means of cutting down the expense.

EARLY DIFFICULTIES.

In the stopes, raises and drifts the lighter 2¼-in. drills would give fairly satisfactory results, as they could, in a pinch, be handled by one man with a little assistance now and then from a mucker or timberman. Still, each drill, even when new, consumed 80 to 90 cu. ft. of free air compressed to 90 or 100 lb. receiver pressure, and the cost of fuel, coupled with the monthly repair bills, often made the mine manager wish he had never seen a machine drill. Then, too, he was caused no end of worry and trouble in getting good runners. One man would break as much ground as was expected of him, but in so doing would likewise break side rods, pistons, pawls, etc. Another would get along with few repairs, but would not get results, evidently from fear of breaking the machine.

One runner preferred one make of drill and another would not have it, so the manager was, to use a common expression, "in hot water all of the time." He could not have several different makes of drills on hand on account of the large stock of repairs he would be forced to carry, and as a consequence had to take such men as he could get and "break in" new runners. For these reasons he kept at the drill manufacturers with suggestions to cut down the number of parts in their machines and make them less complicated and more substantial. His suggestions were taken in good spirit, perhaps, but the machine makers were loath to make any changes whereby the repair bills would be materially lessened, as their real income came from this source.

The larger manufacturers had men covering every camp, and when it became known that a certain property would soon be equipped with a compressor, the manager was beseiged by drill salesmen who offered all sorts of inducements in order to get their machines introduced, knowing well that it was not a question as to what they would make on the original sale, but what orders would come to them for repairs later on. The compressor bought, the manager was forced to decide on some make of drill.

A decision once arrived at, it was seldom that he could be weaned from his first love, and henceforth would be known as a Sullivan, Ingersoll or Rand man, and would spend hours arguing with some fellow operator about the merits of his pet drill, while in his letters sent with orders for repairs to the manufacturer, he would probably accuse this innocent person of sitting up nights figuring how he could change parts of his machine so that the repair bills would mount up. I know one large operator who has been using a certain make of drill for nearly twenty years, but who is always complaining about the maintenance expense and threatens to make a change on the next plant he installs. About the time he is ready to purchase, if approached by the representative of a rival concern, he will argue for an hour or so on the subject and will probably conclude by saying: "Well, I guess I'll stay with the old machine. If I buy yours, I expect I would be jumping from the frying pan into the fire."

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* Read at the meeting of the Colorado Scientific Society, February 2, 1907, Proceedings, Vol. VIII, pp 235-246.

INTRODUCTION OF THE AIR-HAMMER DRILL.

As I said before, many changes have been inaugurated in the past three years in the methods of rock breaking, and from the subject of this paper you will naturally infer that I intend to show what results have been obtained by the use of the air hammer drill. Before offering any argument, however, on the advantages or disadvantages of this type of machine, it might be well to explain how the machine was first used in mining operations and how I came to be personally interested in its development.

About seven or eight years ago I was employed on a property where a great portion of the value of the ore lay in a 6- to 10-in. streak of honeycombed quartz which was frozen to the wall; in fact, the gangue, which made up the major portion of a 4-foot vein, contained little or no value. Our method of mining had been to strip the quartz and take it down on sorting sheets in a filled stope by the use of gads. This was rather slow and arduous work, but the value of the gold was sufficient to leave a small margin of profit, even after excessive hauling, freight and smelter charges were paid. At this time I had occasion to go East to a directors' meeting of the company, where the difficulty of saving the ore was fully explained and, in the discussion which followed, various methods of overcoming the obstacle were considered.

At this time the pneumatic riveting hammer was coming into general use in boiler shops, and one of the directors, who was of a rather ingenious turn of mind, suggested that a hammer of this sort might be brought into play; and by the use of a gad in place of the riveting tool, be used to take down the ore. While I did not think the plan would prove feasible, I consented to visit a boiler shop and even experimented at driving rivets in an effort to ascertain what the possibility might be of using them for the purpose mentioned.

At that time the hammers were not as well designed as they are to-day, and the vibration was so great that I was forced to express the opinion that excessive wages would have to be paid the miners to get them to use the tool. In considering the question, however, one very important point, which has since been brought to light, was overlooked, i. e., that there was much less "kick back" in operating the hammer against rock than against a rivet in the shell of a boiler. The reason for this difference in the action of the tool is probably due to the fact that after the first few blows of the piston against the steel, the elasticity of the boiler sheet is such that it seems to spring back a trifle after each blow of the hammer. As the steel recoils it meets the next blow half way on the rebound and a shock is caused which is very trying on the nervous system of the operator. It has since been proved conclusively that with the improved type of hammer there is very little shock or vibration to inconvenience the operator, and that the remedy does not lie entirely in the improved machines. The conclusion is that, with a gad made with the proper taper, at each blow of the piston the tool is forced into the crevice and remains there until the next blow is struck. This leaves the operator with but the natural vibration of the hammer to contend with. In the later types of machines the piston is made to cushion on live air on the back stroke, and no excessive jar occurs.

FIRST EXPERIENCE NOT ENCOURAGING.

The tools were, however, not put in use at the mine, and although I thought of the subject many times during the three or four years following, and before their trial as hitch cutters in various camps, it was not until nearly three years ago that I had the opportunity of trying them in Cripple Creek. At that time they were being tried for block holing and hitch cutting, and the tool used was a 12-in. hollow piece of steel with about 14 or 16 cutting edges. The manufacturers were claiming great results for both of these purposes and for drilling as high as a 4-ft. hole, finishing about $1\frac{1}{8}$-in. in diameter.

It fell to my lot to attempt to drill a round of holes in a narrow stope in one of the Cripple Creek properties, and I must admit that the result of the test offered no encouragement. The makers of the machine had evidently based their somewhat astounding records on tests made in some very even-cutting soft formation; for, when the drill was operated against Cripple Creek phonolite, it was soon discovered that unless some very radical changes were made in the drill bits they would not do the work. The greatest difficulty was experienced in getting the bits spread to a gage so that they would follow. Then, too, the cutting edges were so fine that it was next to impossible to temper them to stand for more than an inch or two in that character of ground.

Another difficulty developed in the construction of the drill bits. These were made of ⅞-in. hollow staybolt iron, with 6 in. of hollow steel welded to either end for a shank and bit. It was found that crystallization would take place at the welds and either the shank or bit would jump off in a very few minutes. I decided, however, that the machine could be perfected, and with the assistance of my father, who is a mechanical as well as a mining engineer, set about remedying the faults mentioned. We turned our attention at first to the steel, and after careful experiments found that the bits with six cutting edges cut faster and held their gage better than any other style. The cross bit was tried, but was discarded on account of its tendency to "rifle" a hole and "hang up" in crossing slips at an acute angle. We also found that with this shape of bit it was hard work to rotate the drill by hand in soft ground, and, while it cleared better, the six-tooth bits gave much better results. Sharpening tools were made for the six-tooth bits and little difficulty was experienced in drill sharpening after the blacksmith had acquired the knack of spreading the gage.

NECESSARY MODIFICATIONS.

Hollow steel was necessary in drilling down holes or flat holes in sticky ground, as it was essential to force part of the exhaust air through the steel to clear the hole of cuttings. The welded bits would not stand in hard rock, and we were in a quandary as to how we would overcome this difficulty, until it was discovered that a ⅜-in. hole could be drilled through a 4-ft. piece of steel in a gun-barrel lathe. We used this class of steel for some little time, until we found that we could purchase a brand of hollow rolled steel in Sheffield, England.

With these changes we were able to drill 4-ft. holes in any ground at a speed varying with the formation of from 1 to 10 in. per minute. In testing the machine thoroughly, however, we found that a cast-steel cylinder would crystallize easily and we were forced to change the material used in its construction to the best grade of steel shafting, forming the complete cylinder out of the solid metal.

We then found that it was next to impossible to get men who would hold the machine over their heads and drill uppers. One could not blame the drill runners, as it was certainly an awful task to set a man at, and only the very strongest could stand it for any length of time. The screw-feed machine mounted on a light drift column was tried, but finally discarded, when one of the manufacturers constructed an air-feed attachment. With this machine it was possible to "set up" and "tear down" in less than a minute and the drilling capacity of the machine was increased 100 per cent. Machines of this type were placed in all of the larger mines of the country, and it was soon found in competitive tests that they would out-drill any of the 2¼-in. machines.

The manufacturers of the old-line machines soon found that they were rapidly losing ground and began to experiment on the same line themselves. Several new companies were formed, principally by mining men who realized the advantages of the air-hammer drills, as compared with the piston machines,. and during the past year many improvements have been made.

As this brings us down to the present time, it only remains for me to attempt to show why this new type of drill has come to stay, and wherein it possesses advantages over the old-line drills. This I will attempt to do by taking up each class of work separately.

ADVANTAGES OF THE HAMMER DRILL.

In the large crosscut or railway tunnel, the large piston drill still holds the advantage, as it is possible to drill deep rounds and break the ground far more economically and rapidly than would be possible with the small hammer type. Even in this class of work, however, there is a place for the small drill, as they can be used most successfully in block holing and in taking up bottom or trimming up the walls where projections are left, either on account of missed holes, or because the drill runner has miscalculated the load he had on a certain hole. They can also be used for drilling uppers in the roof for pipe hangers, or for putting in short relief holes in the heading where they will give the cut holes a better chance to break.

In shaft or winze work, however, they can be used for drilling the full round of holes and even in the larger sized shafts, records show a saving which is simply astounding. To those who are familiar with this class of work, the reason is obvious. With piston drills, even in the hands of the best of runners, more time is lost in setting up, tearing down, lining up, cranking in and out of holes and in changing steel, than is consumed in drilling. Where the ground is even and breaks well, it is not so bad, but where slips are encountered frequently, and time is consumed in preventing a "hang up," or where the formation is such that a great many holes must be drilled to break the ground, the air-hammer drill has all the best of the argument.

The machine, steel and hose, can all be put into one bucket and the drill runner can be at work in five minutes from the time he goes on shift. The steel being loose in the chuck, he loses no time in changes, and he can start a new hole while a piston drill runner would be cranking out. Holes can be drilled in any direction and pointed to take advantage of any slip. No holes need be lost, as it is practically impossible to get a "fitchured" hole even in the worst kind of ground. All of the holes can be drilled to any depth desired, up to 4 ft., except in very heavy sulphide ore, and the sump holes can be put in in any part of the shaft.

With a piston drill, the runner may get a hole down 3 ft., and then get hung up, and rather than lose time he will take a chance on breaking the ground and start another hole. On this hole he may have no trouble and he will perhaps drill it 6 ft. deep. What is the consequence? When the shaft is cleaned up he will find he has no sump, or one corner of his shaft sticks out so that he is unable to get a set up which will enable him to drill his round to advantage. He may even have to drill a hole by hand and shoot it before he can get in to do any good with his next round. As a consequence, the shifts are thrown out and valuable time is lost. When timbering commences, the small hammer drill is indispensable for cutting hitches and taking out projections where they interfere with the sets, and for these purposes alone, will pay for itself in 30 days.

In a drift, a drill runner can either mount the air-feed drill on a column or, where it is possible to pull the cut out of the top, he can work with the air feed alone, and in any ordinary ground, one man can drill a round of holes in half a shift. Where the cut is pulled from the center or bottom, he can either drill the back and top cut holes off a bar or simply use a stick of timber and butt the air feed against it. I have known of one man breaking 42 ft. in 19 shifts in a drift in granite, and not only did he do all the drilling alone, but the tramming as well.

There is a diversity of opinion as to whether it is advisable to use a 2¼-in. piston drill or an air-hammer drill in this class of work, and a decision, from an economical standpoint, can only be obtained by actual tests. As a usual thing, however, the hammer drill can be used advantageously in all drifts where a 4-ft. round, bottoming 1⅛-in. will break without leaving any "guns." With a piston drill of the size mentioned or larger, it is possible to make more rapid progress but the cost per foot will probably be greater, as much more powder and air will be required and it is a hard matter for a drill runner to set up and tear down without some help from a timberman or trammer. In ground which breaks short, however, the piston drill usually has the advantage, as a larger hole is drilled and the powder can be gotten to the bottom of the holes where it belongs.

COST OF STOPPING.

In stope work the 2¼-in. machine does not have a chance against the air-hammer tool and the records on some of the Cripple Creek properties show that their stoping costs have been reduced one-half since the introduction of the small machines. Where the values lie in small streaks of very high-grade ore, the saving is enormous, as the stopes can be carried even narrower than by hand, as the drill can be run in any place a runner can get his body.

I installed a small machine for a leaser in Cripple Creek some eighteen months ago, and he informed me after his lease had expired, that the little drill was worth $1,000 a month to him. He was stoping on a 14- to 18-in. streak of 4- to 5-oz. ore and found that the ground was too hard to break by hand. He then put in a 2¼-in. machine and was forced to carry his stope 3½ to 4 ft. wide. In doing this he lowered his values to $30 to $35 per ton. After the installation of the little air-feed drill, he was able to break one-third more ore in an 18-in. stope than he had with the

2¼-in. machine in one 3½ to 4 ft. wide. He ran his values back again $80 to $90, cut his hoisting and powder bills down to one-half, and and his timber to one-third, and yet kept his production up to more than the tonnage he was able to get back of the 2¼-in. drill. With the piston machine his air cost him $3 per shift, while with the hammer drill the charge was but $1 for the same length of time. He figured the difference in net returns and found that the small machine saved him a little more than $1,000 per month. The usual method of operating the machine in an open stope is to put in a couple of light sprags well up to the back and about 10 or 12 ft. apart. By putting a 2x12-in. plank on the timbers and drilling from it, a drill runner can fill a stope full of holes in half the time he would consume with a larger drill. Not only can he drill more holes, but he can drill them in any place he desires and take advantage of every slip.

The same method is used in upraising, and data furnished by some of the largest mines in the West shows that a saving of 50 per cent. can be readily given as the average.

REPAIRS.

Not only can more work be done with the hammer drills than with piston machines, but the saving in repairs is well worth considering. In nearly all of the small hammer drills, there is but the one moving part and when properly made this should last for months. The rotation being accomplished by hand, there are no pawls or springs to break and no rifle nuts to wear out. As the machines are fed by air, no feed screws or nuts are required. Taken as a whole, with a properly made air-hammer drill, the repairs are less than 25 per cent. of those of a 2¼-in. machine.

Working at a drill pressure of 100 lbs., a 2¼-in. machine requires 100 cu. ft. of free air per minute, while an air-hammer drill of the valveless type uses but 25 cu. ft. at the same pressure.

Another advantage possessed by the hammer drill lies in the fact that it is not necessary to employ a first-class drill runner, as a good miner who knows how to point his holes will do just as much work after two or three days' experience, as the best man one could hire.

While I could, perhaps, describe the various machines of this type manufactured, and give my ideas regarding the merits and defects of the different drills now on the market, I believe that it would be wise to confine my remarks to the air-hammer drills in general and concluded by saying, as the "old toper" did of brands of whisky, "that they are all good, but some are better than others."

A novel method of utilizing compressed air is described in *Prometheus*, a German scientific periodical. It is especially intended for application to the transport of live fish on railways. Experience has shown that in this connection it is necessary, not, as is usually done, to change the water frequently, but to promote a continuous current of air through it, and it is on this principle that the "compressed air tube" system is based. The open tank containing the water and fish is mounted on a covered railway truck, and air, drawn through a filter outside the car by a small pump, is carried to a horizontal tube or receiver of special composition lying along the floor of the tank, whence it is forced upwards into the water. The air is then allowed to escape at the top. The materials composing the tube are said to impart a special quality to the compressed air. The air pump may be driven either from one of the axles of the train, or by a small engine, but in the former case there is the risk of the supply of air failing when the train stops.

One of the dangers in air compression which has not been fully recognized until within a quite recent period is the liability to explosion in air-compressor cylinders when the heat of compression is caused to exceed the flashing-point of the oil used for cylinder lubrication. Several more or less serious accidents of this nature have been recorded within a period of three of four years.

"It is a well-established fact," state a prominent engineering journal, "that a compressed air system, that is, the air compressor, receiver and discharge pipes, has within itself the potentiality of destructive explosion if the matter of air-cylinder lubrication is indifferently attended to."

It is stated that the proposition for the supplying the entire Cobalt camp (Canada) with compressed air will be carried out. The scheme embraces the using of hydraulic power on the Montreal river to compress the air, which then will be piped to the camp.

COMPRESSED AIR

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THE COMPLETION OF A YEAR'S WORK

With this issue of COMPRESSED AIR the present management completes its first year in the conduct of the paper. The present issue also marks the completion of the term of service of the present Managing Editor, who leaves the paper, not without regret, but with the feeling that the work will be carried on certainly as efficiently as before and, he hopes, much better. He has had the privilege of seeing the paper grow at a most remarkable rate. The number of subscribers has increased over three hundred per cent. and the advertising pages have increased to a satisfactory degree. But, more gratifying than either of these, is the fact that the paper itself seems to have met with the approval and favor of its readers as shown by the numerous letters recently received from prominent engineers containing, it is true, much valuable and, sometimes, strong criticism, but on the whole they would indicate that COMPRESSED AIR as an engineering periodical has maintained its reputation as a valuable and interesting paper.

We sincerely hope that in the future the paper will continue to be able to publish articles of real value and worth, and with the amount of material already on hand, the outlook is exceedingly bright for the accomplishment of this purpose. In order, however, that COMPRESSED AIR may serve its readers to best advantage it is necessary that there be cooperation, and that they send us from time to time accounts of new ways for utilizing compressed air to advantage in the various lines of work in which they may be engaged. If you have succeeded in making a difficult repair by means of pneumatic tools, write us about it and send photographs. By establishing a precedent in these matters, others will be induced to follow your example, and you may obtain many valuable pointers which will greatly assist you in your work.

COMPRESSED AIR ON THE PANAMA CANAL.

The system for furnishing compressed air for the power on the Canal work is now well advanced, the Culebra plant and the one at Empire have been in operation for some months past with gratifying results, while the new plant at Las Cascadas is expected to begin running in a short time.

Good progress has been made in laying and connecting the giant 10-inch air line, and when completed this will extend all the way from Pedro Miguel to Bas Obispo, a distance of over ten miles. The pipe used in this line is of extra heavy wrought iron, ten inches in diameter and tested to withstand a pressure of eight hundred pounds to the square inch. It is believed this pipe will last even under the extreme climatic conditions that prevail on the Isthmus, for a matter of twenty-five years or more.

This air line constitutes the great artery or feeder through which the compressed air is forced, and presents an everready, bottled-up energy of tremendous working force and almost unlimited power; a force that can be tapped at a moment's notice and supplied at will to any and all parts of the work where power of this character is needed. It follows the line of the canal closely and at convenient intervals gate valves and tees are placed, from which branch lines of various-sized pipe convey the air direct to the work. These can be shifted as emergency demands or new ones added, and with the aid of rubber hose present an almost continuous front of power units, equivalent to a long row of stationary engines placed side by side for a distance of ten miles. It is so arranged that this power is available as fast as the line is extended—a feature of immediate importance, as new drills can be hard at work within the expiration of thirty minutes thereafter.

When the two compressor plants at Empire and Culebra were first installed, old marine boilers used by the first French Company were exhumed from the jungles and pressed into service temporarily. With these the compressors have for many months been furnishing motive power for operating the rock crusher plants, rock drills, well drills and for various other purposes, including the testing of air brakes and power for driving pneumatic tools, such as trip, clip, and riveting hammers, used in boiler and machine shops.

The rock drills usually sink shafts for blasting to a depth of from fifteen to twenty-five feet; while well-drill borings are sunk from one hundred to two thousand feet as the case may be, Of the rock drills there are one hundred or more of the new Ingersoll-Rand type in operation, while many of the old "French drills" of the Ingersoll pattern are likewise used and are still capable of doing good service after many years of idleness in the jungle. The operation of drills by compressed air adds greatly to their efficiency and overcomes many of the difficulties experienced where steam is the motive power, not the least being the facility with which air can be conveyed to the most inaccesible point—no matter how distant from the plant itself or point of contact with the main pipe line; points to which it would be inconvenient and economically difficult to apply steam power. The latter rapidly condenses as the distance increases and is not available at all for practical purposes outside of a five hundred foot radius from the boiler by which it is furnished. Another great advantage, as compared to steam, is that compressed air is almost impervious to heat and cold after it has left the receivers and the line can be carried under or over ground; along the bed of a river or other body of water, and still not lose an iota of its effectiveness.

Twelve new and complete sets of horizontal-return-tubular boilers of two hundred horsepower each have been ordered from the States, many of which are already on hand and are being rapidly set up. As fast as these are installed (two for each compressor, making a total of twenty-four in all) the old boilers are discarded; thereby adding materially to the efficiency of each plant. These new boilers will burn either coal or oil, and when the latter is furnished by the oil line, that now crosses the Isthmus, the initial cost of the production of compressed air will be reduced to a minimum.

When fully installed this system will comprise one of the largest compressed air plants in the world and should prove a most potent factor in the early completion of Uncle Sam's great waterway.

Under the able management of Mr. George D. Brooke; the Superintendent of Motive Power & Machinery for the I. C. C. and Panama Railway, and the personal supervision of Mr. James Monahan, Superintendent of Air Compressors, this work is being carried through to a successful conclusion. Mr. Monahan has had over twenty-five years experience in this line of work, usually in the capacity of directing and constructing engineer.

There are now installed, and in full working order, six large Ingersoll-Rand compressors (Imperial Type No. 10), each having a capacity of twenty-five hundred cubic feet of "free air" per minute. In addition to these six more of the same capacity will be added shortly, several of which are already on the ground and in process of erection.

The entire system is so arranged that the air line constitutes a continuous shaft or circuit, so that one or more compressors or all of them combined serve to force the air to the furthermost point in the line. After the air is compressed it is retained and cooled in large air receivers, whence it is conveyed directly to the main pipe or "air line" as needed. The compressors are automatically adjusted and at present maintain an average pressure of one hundred pounds to the square inch at the receivers, and with a very slight but gradual diminution this pressure extends the length of the line, that at the end being a fraction above ninety-five pounds or a trifle less than five pounds lost for the entire distance of ten miles.

TRADE PUBLICATIONS.

Goldschmidt Thermit Co., 90 West Street, New York.—Handsome souvenir book, entitled "The Thermit Welding Process and What It Offers to Transportation Companies"; 20 pages, 9x12, fully illustrated and devoted to the applications of "Thermit" to the making of repairs of steamships, locomotives, car trucks, etc. This welding compound possesses many unique advantages, as it is entirely self-sufficient in its equipment, requiring no permanent installation of any kind for supply of heat or power; the equipment is light and portable; there is no limit to the size of casting that can be welded and welds made by the "Thermit" process are not only perfect joints but act as a reinforcement, since a collar of pure "Thermit" steel is fuzed around the broken part. This book should be very valuable to all those who are interested in making quick, inexpensive and permanent repairs.

Charles Engelhard, 41 Cortlandt Street, New York.—Fifty-six-page descriptive circular, 6x9, devoted to the design and application of the "Le Chatelier" Pyrometer. This Pyrometer is suitable for measuring temperatures between zero and 2920 deg. Fahr. It is constructed in accordance with the specifications of the Royal Physical Technical Institute of Charlottenburg.

The Hisey-Wolf Machine Co., 150 Nassau Street, New York.—Catalogue No. 5, 28 pages, 4¾x6¾, descriptive of the full line of portable electric tools manufactured by this company. Full information is given regarding electrically driven grinders, breast drills, hand drills, radial drills, etc.

Buffalo Forge Co., Buffalo, N. Y.—Small leaflet describing the Buffalo Air Washer and Humidifier. This apparatus removes all dust and smoke from the air entering a ventilation system; regulates the humidity; reduces the temperature in summer over 80% of the initial difference in temperature between the air and the cooling water used; requires no attention or adjusting.

American Steel Wire Co., The Rookery, Chicago, Ill.—*American Wire Rope News* devoted to the construction and application of American wire rope, also containing useful hints on the treatment and care of rope for elevators, yachts and ships.

Ingersoll-Rand Co., 11 Broadway, New York.—Booklet No. 20 A, 20 pages, 11 illustrations describing the new Temple Ingersoll Electric-Air Drill. This novel device not only completely solves the problem of employing electricity in the driving of rock drills but avoids entirely the conditions which make the successful employment of the electric drill impossible. The drill is air operative, with special advantages of its own, particularly in the increased force of the blow struck and the great saving of power. It should be known by all who have any interest in rock cutting.

Joseph T. Ryerson & Son, Chicago, Ill.—*Ryerson's Monthly Journal and Stock List.* April issue of this valuable pamphlet contains articles on the care of locomotive boilers, novel method of making an extension to a large stack, credits and accounts, notes on riveting and many other subjects of interest.

H. W. Johns-Mandeville Co., 100 William Street, New York.—Small leaflet describing the "J-M" Heater portable type for use in residences, hotels, public buildings, offices, theatres, steamships, drying rooms, ovens, etc. They are neat and compact and easily portable.

Joseph Dixon Crucible Co., Jersey City, N. J.—April issue of *Graphite.* This paper contains an article which should be read by all compressed air users. It is entitled "Village Wrecked by Two Explosions" and contains some pertinent remarks on the proper lubrication of air compressor cylinders.

It has been found in practice that the speed of flow in the main compressed air line should not exceed 30 ft. per second. It the velocity exceeds 30 ft., the plant is not running on an economical basis, and the percentage loss will increase with the increase of the velocity. From 4 to 6-in. main lines are sufficient for ordinary practice in mines; a 4-in. line will deliver 480 cu. ft. of free air per minute, compressed to 85 lb., with a loss of 2 to 3 lb. for a line less than 3000 ft. This volume of air is sufficient to run four 3-in. drills. The line may be of cast or wrought iron. Wrought-iron pipes are usually connected by sleeve couplings. An inspection of the main should be made now and then and if the pipe leaks, it must be repaired at once as an air leak is more expensive than a steam leak.

WANTED.

Present address of Chas. G. Eckstein, formerly of Center Street, New York, or any manufacturer or U. S. agent of high pressure compressed air Manesman tubes or seamless drawn steel air receivers.

CHIPPINGS.

The loss of power in compressing air in a receiver and using it in an engine driven by steam would depend to a very large extent on the purpose for which the power was to be used, how far the engine was to be located from the air-compressor, and a number of other factors, but generally speaking, the efficiency is rather low. There are several sources of loss: first, the air-compressor itself, the efficiency of which would probably be 80 to 85 per cent.; second, loss occasioned by pumping the warm air of an engine-room in the case of a stationary plant, which, of course, would not be present if you refer to its use on an automobile; third, friction in the conducting pipes, this being excessive if the pipe is very long, as in the case cited by an engineer of a water-power air-compressor plant transmitting its power three miles to mining machinery through a 24-inch main; but 390 horsepower was delivered of 1,430 generated at the falls. In an extensive system of compressed-air distribution service used in Paris some years ago, it was found impossible to make a commercial success of it, unless the air were heated prior to use. It is also very difficult to entirely prevent losses from leaks. Experiments extending over a number of years have been made in this country with street cars using just such a system as you mention, *i. e.*, air compressed in receivers and expanded in double-acting engines similar to those used with steam. That they were finally discarded as commercially impracticable after long experiment and investigation would appear to conclusively demonstrate that the losses are excessive.

Gasoline air-compressors may often be employed advantageously in work that does not warrant the installation of a steam plant. A 3¼-in. drill will require about 12 h.p., or 12 pints (1.5 gal.) of gasoline, which, at price of 15c. per gal., would make the operation for eight hours come to $1.20, reckoning that the drill is run two-thirds time. There may be also saving in attendance, as compared with a small steam plant. Gasoline air-compressors have been successfully employed in mining work.—*Engineering and Mining Journal.*

If air at atmospheric pressure and 60° F. could be compressed to 100 lbs. gauge-pressure, and all the heat due to the work of compression taken away as fast as generated, so that the temperature during compression would remain constant, the mean effective pressure during one stroke of the air piston would be 30·2 lbs. If, on the other extreme, none of the heat due to the work of compression is taken away, the mean effective pressure during the stroke will be 41·6 lbs., and the terminal temperature will reach 485° F. As the power required for compression is directly proportional to the mean effective pressure, it will be seen that the additional power required in the latter case is 37½ per cent. of that in the former. In practice neither extreme can be reached, for it is impossible to completely cool the air during compression, and, on the other hand, some of the heat of compression will be radiated; but the lower extreme is the ideal, and the nearer it can be approached the more economical will be the work done.

WHAT PNEUMATIC TOOLS ACCOMPLISH.

What an immense gain was made when the wearied hand of man put the powers of nature to work to drive his tools for him. The conversion of the hand tool into a power driven machine marks a new era in man's economic history.

The annual reports of some of the leading pneumatic tool companies calls attention again to another of the revolutionary influences which power driven tools have introduced into industry. Two great industries have especially been effected by the application of pneumatic power to tool working operations. These are mining and the manufacture of steel structures, including the hulls of ships, bridge parts, and steel framework for large buildings. In mining, especially coal and ore mining, the greatest change effected has been to increase the volume of output by steam or pneumatic drills.

The progress of machine mining is illustrated by the report of the mine inspector of West Virginia. There in 1897 fifty-five machines were at work, and the production of coal by machine was a little over 600,000 tons. In 1905 1,158 machines were at work, and the total production was over 10,000,000 tons. In the first of these years 5.12 per cent. of the total coal produced was by machinery, and in the last year mentioned 32.75 per cent. Meanwhile the number of employes connected with the operation of mining machines increased from 652 to 10,137. In 1901 there were ten employes to every machine. In 1905 the ratio was about the same, so that machinery did not apparently in this case reduce the number of employes required, but maintained a more or less constant ratio of addition. In other words each additional machine called for ten additional employes.

The same result of increasing production comes from the use of power driven tools in working up manufactured materials. In the putting together of steel materials for structural purposes, pneumatic tools have been applied mainly in riveting. Yet invention in this single process has immensely cheapened the cost of operation. Other similar processes are likewise affected with similar results. As yet, however, outside of ship yards of the Great Lakes this reduction in the cost of production has apparently not affected our capacity to build ships in competition with foreigners.

Probably the main reason is that in the more progressive ship yards abroad all of our economizing devices have been adopted or adapted, with the result of introducing possibly greater economies than our own inventions have provided for home production. The German ship yards were quick to see the advantage of pneumatic tools in the construction of boilers and steel hulls. The English and Irish ship yards were somewhat slower, but this apparent disadvantage was overcome for the time being only by the greater amount of work for which a high degree of skill had been attained in hand operation.

The lesson to be drawn from this is that no modern country can make any great advance in the arts, whether by introducing mechanical economies or otherwise, without other countries availing themselves more or less promptly. Wonderful as the pneumatic tools are, they are no sooner invented and patented here than the American agent is sent into the foreign field to introduce them and put them in operation.

This is one of the phases of international competition which no tariff can regulate and no trade policy prevent. The age of machinery is dominated by an equalizing tendency in the instruments of economic competition. The greatest contributors to progress at home in the inventive fields are represented in other nations almost simultaneously. So that the actual working equipment of rival nations is not quite so difficult as some of our publicists would have us believe. The inventors and makers of power driven tools are among the world's greatest levelers. But they level up, and not down.—*The Wall Street Journal.*

* * *

INDUSTRIAL.

Goldschmidt Thermit Co. announces the removal of their offices from 43 Exchange Place to the fourteenth floor of the West Street building, 90 West Street, New York. Also that they have opened a branch office at 432-436 Folsom Street, San Francisco, Cal., under the management of Mr. L. Heynemann for business in the States of California, Oregon, Washington and Nevada.

Thomas W. Pangborn Co. announce that the continued rapid growth of their business makes it necessary to enlarge their general offices. They are now occupying a large suite of rooms on the fifteen floor of the new West Street building, located at West and Cedar streets, New York.

The Cleveland-Cliffs Iron Co. has placed an order for a 60-drill Sullivan air compressor for its new Mass Mine at Negaunee, Mich. The machine will be of the Corliss Cross Compound condensing, two-stage type, with large receiver intercooler. The steam cylinders will be 24x46 inches in diameter, with a 48-in. stroke, and the air cylinders 40x24x48 inches, with a displacement capacity of 4000 cubic feet of free air per minute, at 60 r.p.m., or nearly 5000 feet at 70 r.p.m. The compressor will be built at the Chicago works of the Sullivan Machinery Company.

Mr. J. F. W. Bunsen has entered the employ of Muralt & Co., engineers and contractors, New York, and will take charge of their Southern office in Charleston, S. C.

Mr. Bunsen, who is a nephew of the late Prof. Bunsen, the inventor of the burner which bears his name, has had many years' experience in designing and erecting important engineering works. At the time of the Galveston flood Mr. Bunsen was engaged as the mechanical superintendent of the American Cotton Co., Southern District.

U. S. PATENTS
ESPECIALLY PREPARED FOR
COMPRESSED AIR

Full specifications regarding any of these patents may be obtained by sending five cents to tho Commissioner of Patents, Washington, D. C. (Stamps will not be accepted.)

845,135. PNEUMATIC HUB FOR WHEELS. William S. H. Smith, Croydon, England. Filed Sept. 10, 1906. Serial No. 333,993.

845,265. AUTOMATIC AIR-BRAKE COUPLING FOR RAILWAY-CARS. Frank H. Rutherford, Chicago, Ill. Filed April 14, 1906. Serial No. 311,709.

845,275. PNEUMATIC RENOVATOR. Thomas J. Sullivan and George J. Harris, Wilwaukee, Wis.; said Harris assignor to John H. Stouthamer, Wilwaukee, Wis. Filed Nov. 25, 1904. Serial No. 234,303.

845,327. PNEUMATIC CUSHIONING WHEEL-SUPPORT. George W. Bell, Liverpool, England. Filed Feb. 12, 1906. Serial No. 300,560.

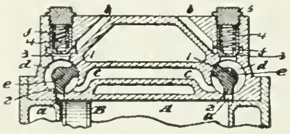
845,500. AIR-BRAKE APPARATUS. Rogert J. Wilson, Pittsburg, Pa. Filed Nov. 16, 1905. Serial No. 287,655.

Claim.—In an air-brake system, the combination of an auxiliary reservoir, brake-cylinder, triple valve and train-pipe, and an automatically-acting ball-valve for throttling the train-pipe.

845,562. APPARATUS FOR SEPARATING DUST FROM DUST-LADEN AIR-CURRENTS. Augustus Lotz, San Francisco, Cal., assignor to Sanitary Devices Manufacturing Company, a Corporation of California. Filed Nov. 14, 1904. Serial No. 232,659.

845,563. PROCESS OF SEPARATING COLID MATERIAL HELD IN SUSPENSION BY AIR-CURRENTS. Augustus L*tz, San Francisco, Cal., assignor to Sanitary Devices Manufacturing Company, a Corporation of California. Filed Nov. 14, 1904. Serial No. 232,660.

845,653. AIR-COMPRESSOR AND THE LIKE. George de Laval, Cambridge, and George P. Aborn, Boston, Mass., assignors to International Steam Pump Company, New York, N. Y., a Corporation of New Jersey. Filed July 15, 1904. Serial No. 216,682.



Claim.—In an air or gas compressor or pump, the combination with the cylinder and its inlet and discharge passages, of spring-closed puppet discharge-valves in the discharge-passages, mechanically-actuated valves between the puppet-valves and the cylinder controlling the discharge-passages, and means for actuating said mechanically-actuated valves to open the discharge-passages at a fixed point and to close the discharge-passages at the end of each compression-stroke and before the closing of the puppet-valves, and maintain the closing of the discharge-passages on the reversal of the piston, whereby a slow-closing movement of the puppet-valves is secured and the puppet-valves ar cushioned in closing, substantially as described.

845,736. COMBINED AIR-BRAKE-SETTING DEVICE AND ALARM. Robert E. Adreon, St. Louis, Mo. Filed Nov. 30, 1906. Serial No. 345,593.

845,841. PRESSURE-REGULATOR BELLOWS. Philip Wuest, Jr., Philadelphia, Pa., assignor to The Auto-Manuel Piano Action Company, Philadelphia, Pa., a Corporation of New Jersey. Filed Nov. 7, 1904. Serial No. 231,706.

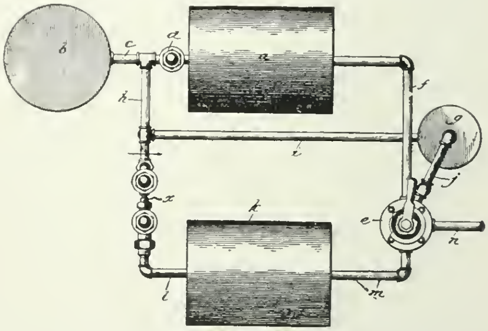
845,842. PNEUMATIC WHEEL. William L. Barnard, St. Louis, Mo. Filed Nov. 28, 1905. Serial No. 289,529.

845,952. DRILL OR BIT ROTATING MECHANISM FOR ROCK-DRILLING MACHINES OR ENGINES. Henry Hellman and Lewis C. Bayles, Transvaal. Original application filed July 12, 1905. Serial No. 269,408. Divided and this application filed June 12, 1906. Serial No. 321,328.

846,305. COMBINED TRAIN SIGNAL AND INDICATING APPARATUS. William A. Harris and Benjamain S. H. Harris, assignors to The Harris Manufacturing Company, Greenville, S. C., a Corporation of South Carolina. Filed March 23, 1904. Renewed June 6, 1906. Serial No. 320,450.

846,306. COMBINED TRAIN SIGNAL AND INDCAITING APPARATUS. William A. Harris and Benjamin S. H. Harris, Greenville, S. C., assignors to The Harris Manufacturing Company, Greenville, S. C., a Corporation of South Carolina. Filed March 23, 1904. Renewed June 6, 1906. Serial No. 320,451.

846,528. AIR-BRAKE SYSTEM. Walter V. Turner, Wilmerding, Pa., assignor, by direct and mesne assignments, to The Westinghouse Air Brake Company, Pittsburg, Pr., a Corporation of Pennsylvania. Filed Aug. 1, 1903. Renewed April 23, 1906. Serial No. 313,320½.



Claim.—In combination, a main reservoir for relatively high pressure, a supply reservoir for relatively lower or train line pressure, an application reservoir for a higher pressure than that of the main reservoir, means for maintaining the desired pressures in these reservoirs, a train pipe and an engineer's valve provided with service exhaust means and having connection to the three reservoirs and train pipe, and adapted to connect the main and supply reservoirs to the train pipe, and to connect the application reservoir to the service exhaust means, whereby such means are operated.

846,640. FORCE-PUMP. Charles Wolf, St. Louis, Louis, Mo. Filed Oct. 15, 1906. Serial No. 339,-089.

846,857. PNEUMATIC TOOL. Herman Leineweber, South Chicago, Ill., assignor of one-half to W. M. Bayne, Chicago, Ill. Filed Nov. 6, 1906. Serial No. 342,179.

847,043. PNEUMATIC TOOL. E4ward B. Boyer, Peoria, Ill. Filed Jan. 2, 1906. Serial No. 294,-119.

847,269. SAND-BLAST APPARATUS. Franklyn M. Wise, New York, N. Y., assignor to American Diamond Blast Company, New York, N. Y., a Corporation of New York. Filed Nov. 10, 1905. Serial No. 286,632.

847,270. SAND-BLAST APPARATUS. Franklyn M. Wise, New York, N. Y., assignor to American Diamond Blast Company, New York, N. Y., a Corporation of New York. Filed Nov. 23, 1905. Serial No. 288,641.

847,273. PROCESS OF DRYING AIR FOR BLAST-FURNACES. Nathaniel T. Bacon, Peace Dale, R. I. Original application filed Jan. 25, 1905. Serial No. 242,697. Divided and this application filed March 13, 1906. Serial No. 305,777.

847,373. PROCESS OF DRYING AIR FOR BLAST FURNACES. Nathaniel T. Bacon, Peacedale, R. I. Original application filed Jan. 15, 1905. Serial No. 252,697. Divided and this application filed March 13, 1906. Serial No. 305,777.

847,278. PNEUMATIC CLEANER. William W. Conover, Toronto, Ontario, Canada, assignor to Sanitary Carpet Cleaner Co., a Company of New York. Filed April 26, 1905. Serial No. 257,547.

847,317. RECHARGING-VALVE FOR AIR-BRAKES. Francis L. Clark, Pittsburg, Pa., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Oct. 18, 1902. Serial No. 127,816.

Claim.—A recharging-valve device for air-brakes, comprising a movable abutment exposed on one side to train-pipe pressure and on its opposite side to a variable fluid-pressure, means actuated by a slight movement of the abutment caused by a slow and gradual increase of train-pipe pressure to open communication from the train-pipe to the auxiliary reservoir, and means actuated by a further movement of the abutment in the same direction to close said communication.

847,394. AIR-PUMP. John C. Beck and John A. Bowyer, Chicago, Ill. Filed Aug. 11, 1906. Serial No. 330,117.

847,433. AIR LIFT-PUMP. Bryan Obear, St. Louis, Mo., assignor to Montague Compressed Air Company, St. Louis, Mo., a Corporation of Missouri. Filed May 14, 1906. Serial No. 316,872.

Claim.—In an air lift-pump, a suitable pump-cylinder, means for admitting thereinto the liquid to be pumped, a pipe leading into said cylinder and discharging air under pressure in a jet directed toward the discharge end of the cylinder, a check-valve located in the cylinder above the discharge end of the air-pipe, a branch leading into the cylinder from the air-pipe above the check-valve, a valve in said branch normally closed when said check-valve is open, and a suitable intake for the cylinder, substantially as set forth.

847,470. AIR-COMPRESSOR. William E. Gray, Vinton, Va., assignor of one-half to John B. Beard, Vinton, Va. Filed July 24, 1906. Serial No. 327,528.

Claim.—In an air-compressing apparatus, a compressor-frame comprising a straight central discharge-pipe disposed longitudinally of the frame, straight lateral discharge-pipes disposed transverse to the frame at opposite sides of the central pipe and each having separate connection therewith, pump-cylinders disposed longitudinally of the frame at the respective corners thereof, each cylinder having each end of its inner side connected to a separate lateral pipe, an outlet-valve in each lateral pipe, inlet-valves located at each end of each pump-cylinder at the outer side thereof, and pistons within the cylinders, the several discharge-pipes and pump-cylinders being located throughout in the same horizontal plane to produce a flat rigid self-contained frame structure.

847,569. MEANS FOR COMPRESSING AIR AND THE LIKE. John Gill, Edinburgh, Scotland. Filed June 3, 1905. Serial No. 263,676.

Claim.—In an apparatus for compressing air or other elastic fluid by means of a descending column of incompressible liquid the combination of a downward pipe *a* and an upward pipe *b* and a closed pipe *c* connecting together the pipes *a* and *b* to their upper ends, an air-reservoir *g* having connected to it the lower ends of the pipes *a* and *b*, a pump *h* for circulating the water or other incompressible liquid, and a blower *i* for delivering the air to be compressed to the downward pipe, substantially as described.

847,587. ROCK-DRILL. Bradford H. Locke, New York, N. Y. Filed April 16, 1906. Serial No. 312,046.

Claim.—A rock-drill having a longitudinal channel and a series of lateral openings therefrom at frequent intervals along its length back of the drill-head, whereby the drill can be successively sharpened without closing the openings other than that next the head.

847,590. ROCK-DRILLING-MACHINE CHUCK. Sigismund R. J. Maynard, Aldrovand V. T. Maynard, and Frank Gale, Fordburg, Transvaal. Filed Nov. 13, 1906. Serial No. 343,299.

847,729. ATTACHMENT FOR VACUUM CLEANING SYSTEMS. George Clements and James M. Hostler, Chicago, Ill., assignor to Hygienic Renovating Company, a Corporation of Illinois. Filed April 4, 1906. Serial No. 3[illegible].

Claim.—A device of the character described comprising a base, a transparent dome carried by the base, an outlet-pipe opening at its upper end into the top of the dome and leading outwardly through the base, and an inlet arranged tangentially to the base

847,785. AIR-PUMP. Paul E. Kleineberg, Croton Falls, N. Y. Filed Feb. 26, 1906. Serial No. 302,920.

847,941. PNEUMATIC BUFFER. Melvile P. Hayward, Quincy, Mass. Filed Feb. 13, 1906. Serial No. 300,920.

847,947. APPARATUS FOR REMOVING DUST. David T. Kenney, North Plainfield, N. J., assignor to Vacuum Cleaner Company, North Plainfield, N. J., a Corporation of New Jersey. Filed Nov. 29, 1901. Serial No. 84,058.

847,946. ROTARY AIR OR FLUID COMPRESSOR. Charles A. Kaiser, Astoria, N. Y., assignor of one-third to Leo Flatow, New York, N. Y. Filed Feb. 10, 1905. Serial No. 245,157.

847,944. PRESSURE-REDUCING VALVE. Josef Hubner and Isidor Mayer, Vienna, Austria-Hungary. Filed Feb. 19, 1906. Serial No. 301,917.

848,341. APPARATUS FOR MOISTENING AIR. Harry Bentz, Larchmont, N. Y. Filed Jan. 18, 1907. Serial No. 352,868.

848,255. PNEUMATIC ENGINE. Edward Leichter, Nevada City, Cal., assignor of one-fourth to J. C. Campbell, Nevada City, Cal., and one-fourth to John Bender, Hamilton, Ohio. Filed Jan. 24, 1906. Serial No. 297,544.

849,333. AIR-COMPRESSOR AND INTERCOOLER. John G. Leyner, Denver, Colo. Original application filed Oct. 1, 1902. Serial No. 125,539. Divided and this application filed Sept. 2, 1903. Serial No. 171,625.

849,229. ROCK-DRILL. Frederick E. Glaze, Victor, Colo., assignor to The Eureka Drill Steel Company, Cripple Creek, Colo., a Corporation of Colorado. Filed Jan. 31, 1906. Serial No. 298,878.

849,187. SCRAPER FOR DISK DRILLS. Edwin R. Beeman, Minneapolis, Minn., assignor to Monitor Drill Company, St. Louis Park, Minn., a Corporation of Minnesota. Filed July 26, 1906. Serial No. 327,946.

849,190. ANGLE-COCK FOR AIR-BRAKE SYSTEMS. Joseph A. Bennett, Youngswood, Pa. Filed Nov. 7, 1906. Serial No. 342,398.

849,049. PNEUMATIC TIRE. Lorwin N. Cates, St. Louis, Mo. Filed March 28, 1906. Serial No. 308,590.

848,852. AIR-INLET VALVE. Patrick H. Reardon, San Francisco, Cal. Filed Dec. 27, 1904. Serial No. 238,540.

848,775. AIR-COMPRESSOR. Wilson Selakosky, White Haven, Pa. Filed Aug. 6, 1906. Serial No. 329,427.

848,271. VALVE CONTROL FOR PNEUMATIC ELEVATORS. George F. Steedman, St. Louis, Mo. Filed March 12, 1906. Serial No. 305,654.

849,051. POWER-TRANSMISSION DEVICE. Alexander Churchward, Pelham, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Sept. 6, 1902. Serial No. 122,382

849,506. ROCK-DRILL. Charles E. Shadall, Milwaukee, Wis., assignor of one-half to Frederick L. Horneffer, Milwaukee, Wis. Filed March 31, 1905. Serial No. 253,018.

849,550. AIR-BRAKE MECHANISM. Charles G. Lundholm, Otis, Cal., assignor of one-half to Frank E. Davisson, Los Angeles, Cal. Filed July 16, 1906. Serial No. 326,515.

849,597. COMPRESSOR-VALVE. Niels A. Christensen, Milwaukee, Wis. Filed March 21, 190[illegible]. Serial No. 199,228.

850,128. PNEUMATIC KNEE-BOOT FOR HORSES Robert C. Bever, Worcester, Mass. Filed Feb 24, 1906. Serial No. 302,709.

850,181. PNEUMATIC CUSHION. Vaclav H Podstata, Dunning, Ill. Filed April 21, 1906. Serial No. 313,033.

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COMPRESSED AIR

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JUNE, 1907.

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THE COMPRESSED AIR BAR

By A. C. Musehold, St. Louis, Mo.

The Pressluftstabzuführungs-Gesellschaft m. b. H. of Berlin, Germany, has filed patents at Washington for an invention that has met with striking success on the European Continent. The object of this invention is the compressed air bar, which is chiefly used for:

1. Keeping fish alive during transports over long distances, be it by special fish railroad cars, ocean or lake and river steamers, or storage of live fish and other gill-breathers in tanks, aquariums, terrariums, etc.

2. Eliminating iron from water ("des-ironing") for drinking water, and water used for industrial purposes, such as breweries, paper manufactories, dye works, laundries, etc.

3. Medical baths ("pearl air baths").

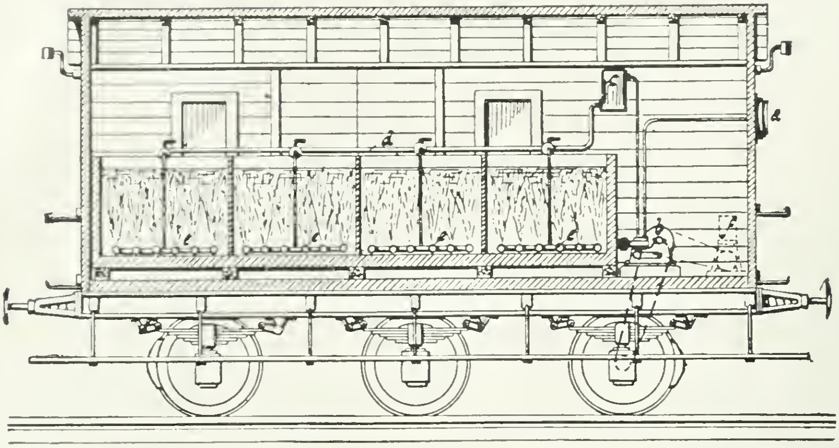
4. Charging and mixing intimately gases with liquids of any kind.

In a bar-like body compressed air is stored up and led off to that liquid, upon which it is intended to have effect. This bar, which is connected to a system of pipes, is fed by means of a pump with air or gas of any desired density, being controlled in such a manner that the air or the gas flows out under a pressure adapted to the purpose wanted, and running through the liquid from down below up to the surface. In order to attain a perfect aeration of the water or other liquid, the compressed air bars must be placed at the bottom of the tank, and the air in the bar must be under a pressure that is greater than the pressure of the liquid that is above them. Since the pressure exerted by a column of water of 10 meters height is but 1 atmosphere, it is evident that it is only a small amount of density-pressure which is required in practice.

The importance of this invention was suggested by the fish merchants, Jacob Bros., of Berlin, who were aiming at keeping fish alive for long periods of time, such as during long journeys on the railroads and in stationary tanks. The process hitherto used for this purpose was that fresh water was forced under sufficient pressure into the tanks, to form a jet. Although air is carried away by the jet of water, it is plain that the greater the quantity of water in the tank, the less aeration there is proportionately.

Experience, however, has taught that in order to keep fish alive the renewing of the water is less important than a continuous thorough aerating of the water used. This aerating is the more necessary the greater the quantity of fish is in proportion to that of the water in which they are to live.

These were the points of consideration, the result of which is the following arrangement for transportation of live fish by special fish railroad cars, as shown by Fig. 1. Through filter "a" air is sucked by the air pump "b" and

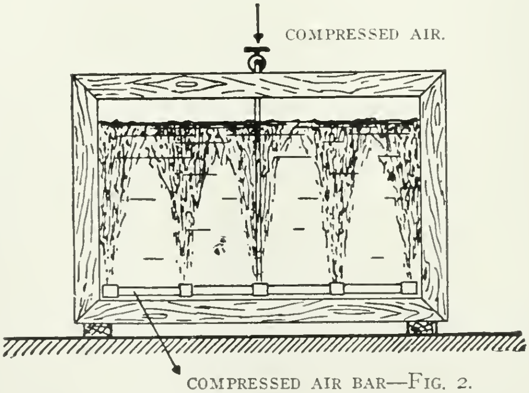


SPECIAL FISH-RAILWAY CAR—FIG. I.

forced into the branch pipes connected with them, to the compressed air bars at the bottom of the fish tanks. From these bars, very fine streams of fresh air flow into the water and mount up to the surface (Fig. 2). The strength and quantity of air supplied to each tank can be perfectly controlled by cocks and valves in the pipe-lines.

The air-pump can be operated either by belting from the axle of the car or by a little motor "f." Although the first way of operation is less expensive, it is dependent upon the movement of the car. Therefore, in order not to stop the supply of air when the car stops for any length of time, the motor will be indispensable, and it will be the only means for stationary tanks.

According to the experience of the Berlin fish merchants, Jacob Bros., the tanks provided with the compressed air bar system, can not only be filled with a considerably greater quantity of fish than formerly, but the duration of transportation can be greatly increased. Live fish have been transported repeatedly on the way for eighty-two hours with the greatest success. In such cases, cars of 75 per cent. load require but 25 per cent. water.



COMPRESSED AIR BAR—FIG. 2.

The adaptability of the compressed air device for thoroughly aerating water, on account of its striking simplicity, made it possible to use this system, for eliminating iron from water. Also in this country the subsoil and spring-water contain so much dissolved iron that it must be eliminated, in order to be used for the municipal supply and for technical establishments, such as dye works, laundries, paper mills, breweries, etc. The process hitherto used for this purpose consisted usually of a supply of air, the oxygen of which transforms the iron that is found in the water in the shape of protoxide salts, to hydroxide, which is indissolvable in water and can therefore be separated from it by mechanical means.

The ways and means of filtering are, however, of great variety. In most cases the water is forced through sprays (shower devices), in order to aerate it on gravel heaps; or, the water ripples through coke, etc. In order to insure sufficient aerating of the water, such plants must be often of considerable height, and, naturally, the lifting of the water requires correspondingly powerful pump works. This is not necessary when plate filters made of artificial sandstone are used; such an arrangement will, however, be more complicated.

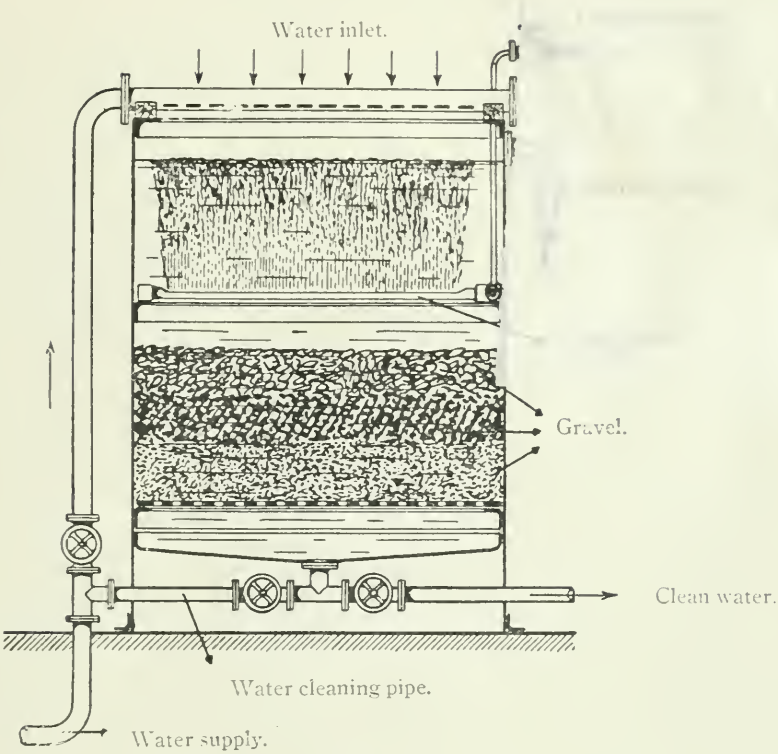
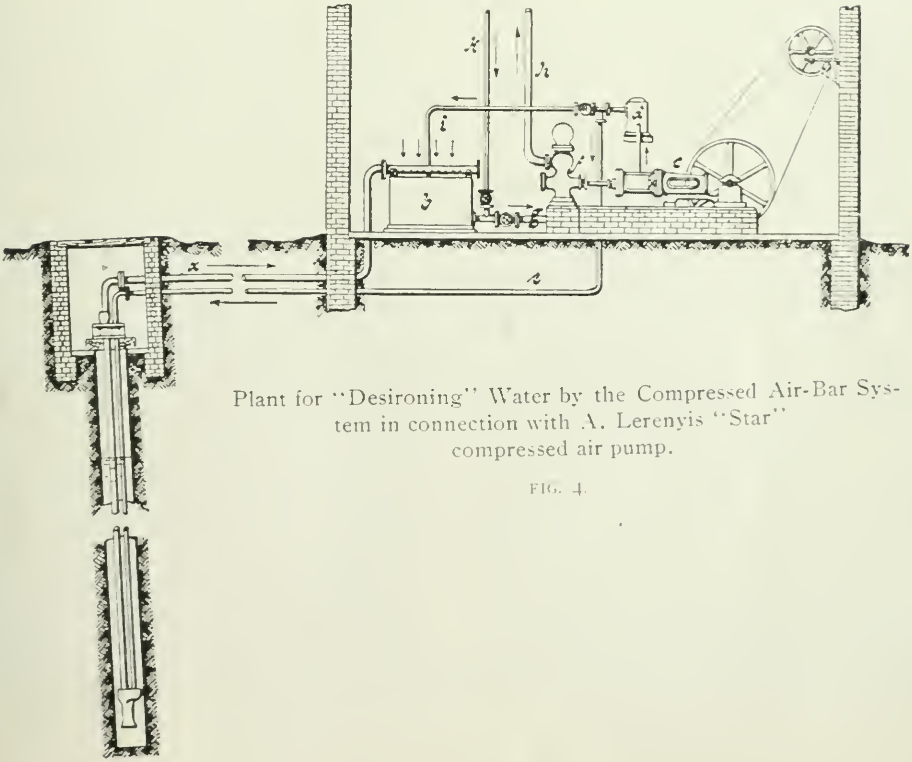


FIG. 3.



Plant for "Desironing" Water by the Compressed Air-Bar System in connection with A. Lerenyis "Star" compressed air pump.

FIG. 4.

Essentially more simple is the installation of a compressed air bar "des-ironer" the general arrangement of which is shown in Fig. 3. For an intimate aeration of the water we need but a comparatively small quantity of air at low pressure. for which reason only a comparatively little power is necessary to operate the whole plant. which can be very much smaller for an equal quantity of water than all other plants for "des-ironing" water.

A "des-ironing" plant in connection with a compressed air pump is shown in Fig. 4. Through pipes "a" the water lifted by means of compressed air pump "c" to the "des-ironer" "b," which is provided with a compressed air bar filled up with compressed air, through piping "i" from the air receiver "d," which is fed by the air pump. The "des-ironed" water is taken through piping "g" by means of forcing pump "f" from the "des-ironer," and pressed through piping "h" into the high-level service tank for used water. The cleaning of the "des-ironer" is done in the usual way by return water, by means of pipe "k."

Also for medical purposes the compressed air bar gives excellent results. i. e.. for oxygen-pearl-air baths. The compressed air bar can be installed for any bath tub; the only outfit necessary is a tank of compressed air with reducing value. about 7 ft. of high pressure hose and the compressed air bar, which fits any bath tub. Medical authorities consider it especially good for reducing flesh.

One tank of compressed air is sufficient for about forty baths, depending on the time of each bath. and costs but a few cents.

The simplicity of the arrangement of the compressed air bar in industrial establishments would make it desirable. and it should prove as useful in the special fish cars and storage tanks of this country. as it is in those plants now in operation in Europe.

PREVENTION OF ACCIDENTS TO WORKMEN.

By Charles M. Ripley.

One of the hazardous undertakings made necessary by demands of commercial and financial interests to-day. is the digging of deep foundations for skyscrapers. Wherever there is considerable water encountered underneath the surface of the ground. as is the case on Manhattan Island south of about Fulton street, it has been almost universal practice of late years to employ the Pneumatic Caisson Process where the buildings are to be of twenty stories or more. This process greatly resembles the tunnelling work now being done under the Hudson River for the terminals of some of the railroads centering in New York. These caissons are, however, carried down vertically to bed rock, instead of horizontally across the bottom of the river; in both cases, however, compressed air is employed to prevent the water running in and flooding the working chamber—a catastrophe, the results of which need no comment.

This particular daring work is done in the face of peculiar and unexpected accidents, which only experience has taught to the contractors, and which only care and proper surveillance can be relied upon to prevent.

The unexpected character of these accidents is well illustrated by recalling the loss of perhaps a score of workmen's lives a few years ago in the old tunnel, now known as the McAdoo tunnel. Of all unexpected occurrences, down under the river. with the tons of water above them, only partially kept out by the compressed air employed for that particular purpose, perhaps the most unlooked for holocaust was *fire*. This experience which was due first to carelessness in enforcement of rules and was most destructive owing to the excess of oxygen in the air—one of the greatest possible stimulant to a conflagration. Mr. C. L. Brown, general superintendent of The Foundation Co., 35 Nassau street, New York, spoke at some length on this subject and stated that his company had for this particular reason installed electric lighting systems within the caissons while constructing the foundations for the twin Trinity buildings, the U. S. Express building, and the Singer building. The interior of a caisson of the regular type employed by this company contains electric lights, and the air whistle for signalling to men outside of the caisson or working chamber during regular cycle of work or in an emergency.

Where men, ascending from or descending to work, struck by the descending buckets or possible falling material dislodged above, this company adopted the most thorough protection by providing separate passageways for men and for materials. The right hand portion has a ladder for men and the left is used for the raising and lowering of buckets and material only. The ladders were put on that side of the shaft farthest away from material and passing buckets. This preserves the workmen's hands from any possibility of being crushed.

Carrying out this same idea of separating men from the hoisting shaft, the foundation company have designed some of their air locks with a separate exit for men, operating independently of that for materials. Five of the caissons sunk for the Singer building foundations were topped with this style of air lock.

The admirable simplicity of this air lock is such that never have the doors become bound fast—a circumstance which has been known to imprison the workmen within the high pressure zone below. Another feature of this air lock which adds to the safety of the men is the fact that the bucket can be lifted to the open air in one continuous haul. This is the basis of the patent taken out by Mr. Daniel E. Moran, C. E., New York. The direct bearing of this feature is that were the material first hoisted to one level by one cable, and then hoisted from there to the open air by another cable, the act of transferring the bucket from one hoisting apparatus to the other is hazardous to every workman below.

There are two separate pipes employed to supply the men with requisite air pressure. In case one were to fail, the gauge tender would instantly detect the changes in the pressure and switch over to the other tube. The gauge tender is to the sand hog in the caisson about what the man at the air pump is to the deep sea diver—if the pressure were reduced, water would flow in and drown the men, while if the pressure were to grow too great, considerable suffering from the bends would result beyond doubt.

In addition to this paralleling of the air pipes, all the steam pipes are installed in duplicate also. This makes almost impossible a sudden cutting off of air supply. The company also has in reserve constantly an additional air compressor to act if an emergency should arise where their men's lives were at stake.

It is oftimes necessary in sinking these caissons to bed rock to add several tons of additional weight on the top. This was done in the past by employing workmen to carry pig iron by hand and pile it up in place. Through their own carelessness entirely it was found this method involved considerable peril to the workmen, and the company then designed a two-ton cast iron weight. A special shackle is cast into the weight for the purpose of rapid and safe handling by machinery. Since these were ado
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COMPRESSED AIR INEXPENSIVE.

The majority of people are of the opinion that to compress air or to employ it at industrial plants is very expensive. This is a mistake, for it can be compressed at low pressure very economically, although its field for operation is limited, and it is only at high pressures that it is expensive.

According to some authentic data recently received, "it takes 114 horse-power to compress 770 cubic feet of free air per minute to 60 pounds pressure per square inch, while 128 horse-power will compress 1,850 cubic feet of free air per minute to 20 pounds of pressure; therefore, at a cost of but 14 horse-power additional, 1,080 *more* cubic feet of free air can be compressed to 20 pounds than to 60 pounds, clearly proving the economy of using a low pressure. The horse-power developed to compress 100 cubic feet free air from atmosphere to 60 pounds is 13.41, and to 20 pounds, 6.28. This is a saving in favor of the lower pressure of 7.13 horse-power, or 53 per cent.

"In compressing air to a high pressure, great heat is generated. This means loss of power, for it takes power to make heat—*and power costs money*—it also necessitates the building of heavy water-jacketed compressors to withstand the high pressure and reduce the heat. On the other hand, in compressing air to a low pressure very little heat is generated; the compressor can be built of comparatively light material and with no water jacket if desired."

Interest has been aroused at Naples by a motor invented by Giovanni Dileo, a resident of Andria, twenty-two years old. The motor is operated by compressed air, and the inventor says that he has solved the principle of perpetual motion.

THE FLOW OF AIR IN LONG TUBES WITH SPECIAL REFERENCE TO PNEUMATIC DISPATCH.

By B. C. Batcheller..

PART III.

THE CO-EFFICIENT OF FRICTION.

FORMULÆ FOR COMPUTING *f*.

The value of the co-efficient of friction **f** may be determined experimentally by measuring the air pressure at two points of known distance apart in a tube through which a constant current of air is flowing, and at the same time determining the quantity of air flowing per unit of time or the mean velocity of the air or the time of transit of a particle of air between the two points at which the pressure is measured. The temperature of the air should also be noted. From this data the co-efficient can be computed by substituting in the formulæ of Part I.

by transforming equation (16)—

$$f = 962.6 \frac{t^2 d\ (461 + r)}{L^3} \frac{(p_1^2 - p_2^2)^3}{(p_1^3 - p_2^3)^2}$$

an equation in which the values of the pressures, time and temperature can be directly substituted.

If the initial velocity of the air can be meastured, then *f* can be computed by transforming equation (13) thus:

$$f = 427.8 \frac{d\ (461 + r)\ (p_1^2 - p_2^2)}{u_1^2 L \qquad\qquad p_1^2}$$

Since *f* is a factor in nearly all our formulæ, it is important that its value should be determined experimentally under all possible conditions to ascertain if it is constant or variable, and if variable what its relations are to other factors of the formulæ.

Prof. Urwin has pointed out that *f* varies with the diameter of the tube, and he cites numerous experiments to prove such a relation. He has suggested an empirical formula, to express the relation between *f* and d, which fits the experiments thus far made very well. It is this:

$$f = 0.0027 \left(1 + \frac{3}{10\ d}\right)$$

in which d is the diameter of the tube in feet.

This formula is shown graphically by a curve, Fig. 13.

The suggestion has also been made that *f* varies somewhat with the velocity of the air, and my own experiments seem to indicate this to be a fact, but sufficient experiments have not been made to speak positively on this point.

First Philadelphia Experiments 6⅛-Inch Tube.

My first experiments were made in Philadelphia October 24, 1896, with the 6⅛-in. postal tubes that extend from the general post office to the branch post office in the Bourse. The time of transit of a light aluminum carrier between the two offices was carefully measured. The carrier had a cup leather packing attached to the rear bearing ring, to prevent the escape of air past it while it moved through the tube. The resistance of the carrier affected the initial pressure only 4/10 of 1 per cent. The air pressure in the tube was measured at the post office and at the Bourse with mercury manometers that could be read to 1/100 of an inch. The arrival and departure of the carrier at the Bourse was signaled at the post office by means of an electric circuit and a bell. The time of transit of the carrier was noted with a stop watch which could be read to quarters of a second. Unfortunately the temperatures of the air were not taken in these early experiments, but probably the error in estimating it was not large.

The straight part of the tubes are of cast iron, bored smooth on the interior. The bends, of which there are seven in each tube, are seamless brass.

The following tables give the results of these experiments.

East-bound tube L....................2992 ft.
East-bound tube..................L = 2992 ft.
Diameter of the tube..................0.5104

Number of Experiments	Pressure at Post Office, Inches of Mercury.	Pressure at Bourse, Inches of Mercury.	Time of Transit, Seconds.	f Computed by Formula (35)
1	10.60	5.83	64.	0.00433
2	10.56	5.76	63.5	0 00431
3	10.60	5.76	63.	0.00426
4	10.77	5.84	63.	0.00433
5	11 02	5.97	62.25	0.00431
6	10.94	6.02	62.25	0.00420
			Mean	0.00429

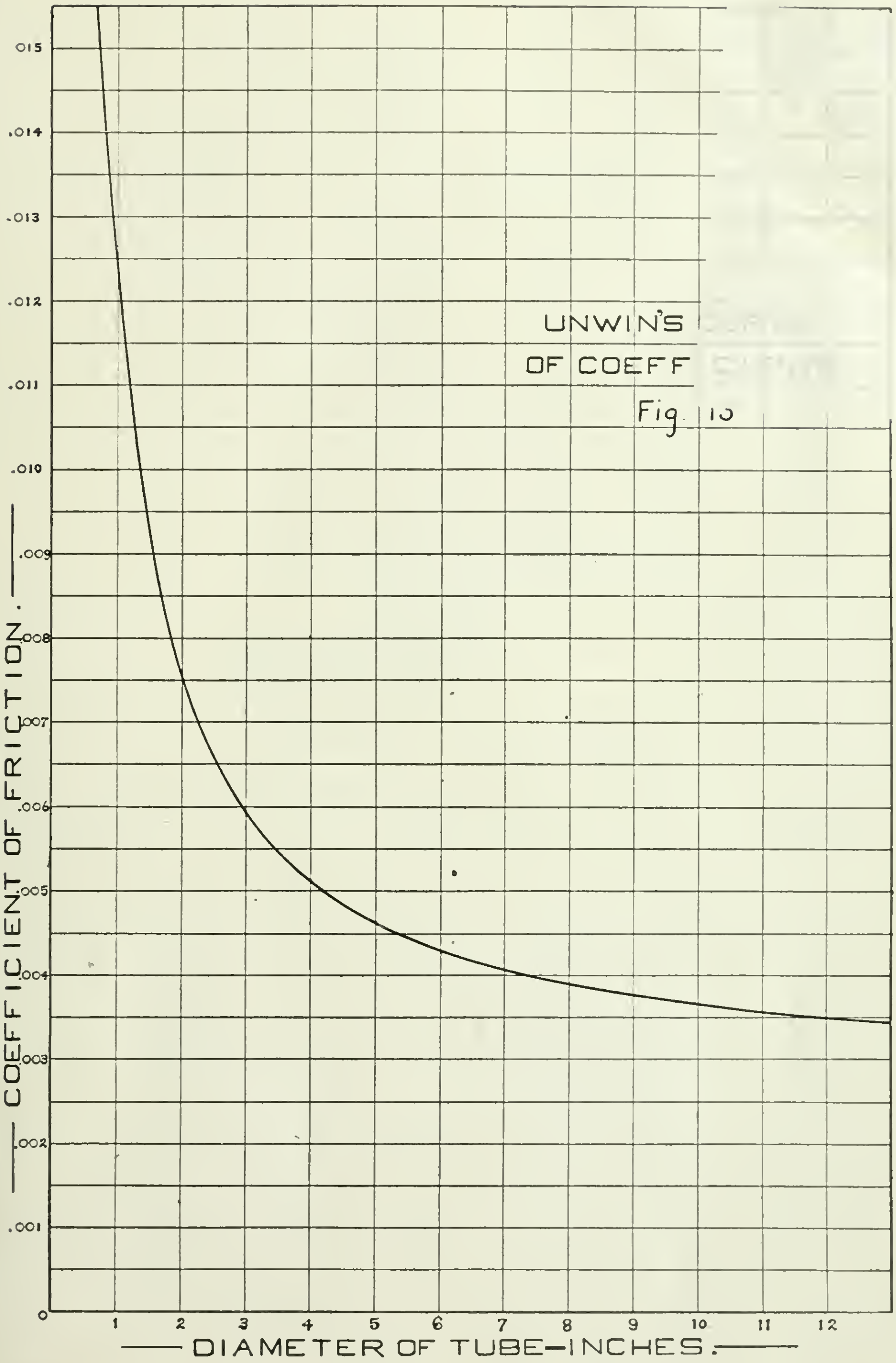
UNWIN'S
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Fig. 15
COEFFICIENT OF FRICTION.
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12
DIAMETER OF TUBE—INCHES.

WEST BOUND TUBE. L=2978 feet.

1	[illegible]	5.69	59.	0.00432
2	[illegible]	5.60	60.	0.00441
3	[illegible]	5.57	59.	0.00422
4	[illegible]	5.67	59.	0.00430
5	[illegible]	5.80	57.25	0.00411
6	[illegible]	5.82	57.75	0.00422
			Mean	0.00426

NOTE.—The pressures are given in inches of mercury above the atmosphere,

Prof. Urwin's formula gives for a tube 0.5104 ft. diameter:

$$f = 0.0027 \left(1 + \frac{3}{10 \times .5104}\right)$$

Second Philadelphia Experiments, 6⅛-In. Tube

Five years later, June 28, 1901, I made another series of experiments, using this same tube, with carrier velocities that varied from about 20 to nearly 70 ft. per second. The method of conducting these experiments was substantially the same as in October, 1896. Special pains were taken to secure results of a high degree of precision. Manometers were constructed with means for dampening the oscillations, thereby increasing the accuracy of the readings. Corrections were made for the displacement of the zero and for the depression of the mercury in the reservoir. Barometer readings were taken frequently, which added to the corrected manometer readings, gave the absolute pressures. Pressure readings were observed every fifteen seconds during the transit of the carrier and the mean taken to compute results. Very low pressures were measured with a water instead of a mercury column. The time of transit observations were corrected for any error in the rate of the watch. In most of the experiments two independent observers noted the time of transit with stop watches. The temperature of the air in the tube was measured with thermometers in the stations and in a vault under the street. The portion of the tubes under ground were assumed to have the temperature indicated by the thermometer in the vault, and the portion in the stations a temperature that rose gradually from the temperature of the ground to the temperature indicated by the thermometers at the stations. On this basis a mean temperature was computed. A light aluminum carrier was used, with an elastic rubber packing attached to one of the bearing rings, that pressed air tight against the surface of the tube. A piece of thin sheet rubber was found to make a much more effective packing than leather, because of its greater elasticity and its tendency to cling to the surface of the tube. It increased the friction of the carrier somewhat, but it made certain that no air escaped past the carrier. A section of the packing is shown in Fig. 14. The speed of the air compressors was changed to vary the velocity of the air, and the experiments were arranged in groups, the velocity being approximately constant in each group.

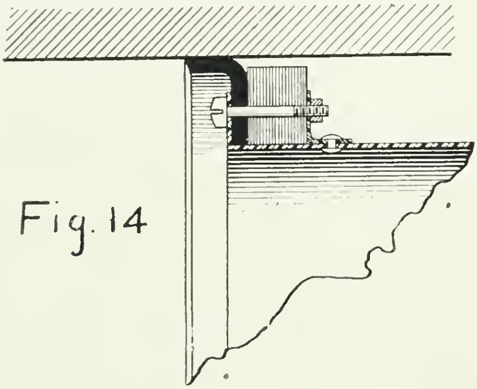

Fig. 14

The air compressor was located in the post office, and the air, which was above the atmospheric pressure in all parts of the tube, flowed from the post office to the Bourse in one tube and returned in the other, the return end being open to the atmosphere at the post office.

The following tables are a summary of the results:

EAST BOUND TUBE—June 28th, 1901

L=2992 feet. d=0.5104 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury, p_1	Mean Final Absolute Pressure. Inches of Mercury, p_2	Time of Transit. Seconds, t	Absolute Temperature, Fahrenheit. T	C… Con… For…	[illegible]
1	35.386	32.852	88.38	538.	0	[illegible]
3	35.547	32 661	81.86	538.	0 0	[illegible]
5	35.531	32.666	81.23	538 5	0.0	[illegible]
7	35.421	32.604	82.61	538.5	0.0	[illegible]
9*	39.698	38.443	144.61	538.5	0.00	[illegible]
11	38.830	34.668	67.79	539.	0.00	[illegible]
13	38.738	34.604	67.79	539.	0.004	[illegible]
15	39.068	34.799	67.79	539.	0.004	[illegible]
17	39 249	34.860	67.79	539.	0 004	[illegible]
19	39.082	34.798	67.79	539.5	0.0046	[illegible]
21	43.219	36.800	56.74	539.5	0.004524	52.73
23	43.432	37.270	56.24	540.	0.004237	53.20
25	43.443	37.310	56.49	540.	0.004252	52 97
27	43.458	37.282	56.49	540.	0.004282	52.97
29	43.434	37.288	56.62	540.	0.004282	52.84
31	47 702	39.718	51.10	540.5	0.004180	58.55
33	47.178	39.410	50.97	541.	0.004091	58.70
35	47.267	39.471	51.10	541.	0.004098	58.55
37	47.163	39.352	51.35	541.	0 004178	58.27

*Valve in outlet of West Bound Tube partly closed.

WEST BOUND TUBE—June 28th, 1901.

L=2978 feet. d=0.5104 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury, p_1	Mean Final Absolute Pressure. Inches of Mercury, p_2	Time of Transit. Seconds. t	Absolute Temperature. Fahrenheit. T	Coefficient of Friction. f Computed by Formula (35)	Mean Carrier Velocity feet per Second. Um
2	32.661	29.958	79.09	536.5	0.004785	37.65
4	32.685	29.959	78.22	536.5	0.004611	38.07
6	32.652	29.961	78.84	536.5	0.004734	37.77
8	32.606	29.962	79.59	536.5	0.004744	37.42
10	——	Lost.	——	——	Lost.	——
12	34.471	30.430	63.41	536.5	0.004431	46.96
14	34.501	30.437	63.53	536.5	0.004470	46.88
16	34.653	30.456	62.27	536.5	0.004423	47.82
18	34.660	30.472	61.77	536.5	0.004342	48.21
20	34.639	30 462	62.65	536.5	0.004456	47.53
22	36.904	30.792	50.72	536.5	0.004099	58.71
24	36.898	30.788	50.72	536.5	0 004098	58.71
26	36.882	30 784	50.60	536.5	0.004072	58.85
28	36.884	30.784	50.72	536.5	0.004093	58.71
30	36.889	30.781	50.85	536.5	0 004119	58.56
32	38.551	31.018	45.45	536.5	0.003938	65.52
34	38.954	31.096	44.57	536.5	0.003921	66.82
36	38.821	31.096	44.44	536.5	0.003841	67.01
38	38.905	31.084	44.94	536.5	0.003972	6627.

In order to compare the co-efficients with the velocity of the air, the mean velocity of the carrier is given in the last column.

First Philadelphia Experiments 8⅛-In. Tube.

On May 5, 1901, a series of experiments were made in Philadelphia with the 8⅛-in. tubes that are used to transport mail between the general post office and the Pennsylvania Railroad station at Fifteenth and Market streets. Like the tubes leading to the Bourse, these tubes are of cast iron, bored, with bends of seamless brass; the bends, however, are one-quarter of an inch larger in diameter than the straight part of the tube. In computing the values of the co-efficient the average diameter was used, but the bends are such a small part of the circuit that their effect is very slight. A small correction was made in the pressures for the resistance of the switches opposite the Reading Railway station. The experiments were made in the same manner as those already described with the tube to the Bourse. The power was supplied by an air compressor located at the Pennsylvania Station, which pumps directly into the tube. The air flows to the post office and returns, the pressure in the tube being at all points above atmospheric. The return end of the tube is open to the atmosphere.

The two following tables give the results of fourteen experiments:

EAST BOUND TUBE—MAY 5, 1901.

L=3882 feet. d=0.6778 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury. p_1	Mean Final Absolute Pressure. Inches of Mercury. p_2	Time of Transit. Seconds. t	Absolute Temperature. Fahrenheit. T	Coefficient of Friction. f Computed by (35)	Mean Carrier Velocity, Um
1	40.540	35.405	75.33	523.	0.003967	51.533
2	40.591	35.345	69.05*	523.	0.003374	56.220
3	40.575	35.449	75.58	523.	0.003982	51.363
4	40.581	35.447	75.20	523.	0.003948	51.622
5	40.541	35.416	75.58	523.	0.003985	51.363
6	40.552	35,405	75.33	523.	0.003977	51.533
7	40.570	35.417	75.33	523.	0.003979	51.533
8	40.563	35.419	75.33	523.	0.003972	51.533

Mean (Omitting 2)..0.003973

WEST BOUND TUBE.

L=3884 feet. d=0.6778 feet.

9	35.280	30.058	68.8	522.7	0.003898	56.454
10	35.278	30.057	69.05	522.7	0.003890	56.249
11	35.230	30.054	69.17	522.7	0.003910	56.152
12	35.235	30.053	69.17	522.7	0.003913	56 152
13	35.265	30.052	68.92	522.7	0.003907	56.355
14	35.262	30.049	68.55	522.7	0.003865	56.659

Mean................0.003897

*In experiment No 2 there was evidently an error in observing the time of transit.

By Prof. Unwin's formula the value of the co-efficient for a tube 0.6778 ft. diameter is

$$0.0027 = 1 + \frac{3}{10 \times 0.6778} = 0.003895$$

Second Philadelphia Experiments 8⅛-In. Tube

After the experiments of May 5 and June 28, 1901, I decided to make another series with the 8⅛-in. tube from the post office to the Pennsylvania Station, taking greater pains to have the packing of the carrier air tight, and making more accurate measurements of the frictional resistance of the carrier during the experiments. To this end the friction of the carrier was measured frequently during the experiments by pulling it through a section of the tube with a spring balance. The resistance was considerable at the beginning of the experiments, but diminished as the packing became worn. The measurements of carrier resistance are plotted in Fig. 15, with the numbers of the experiments as abscissæ. A smooth curve was drawn and ordinates of this curve were used to correct the initial pressures by subtracting

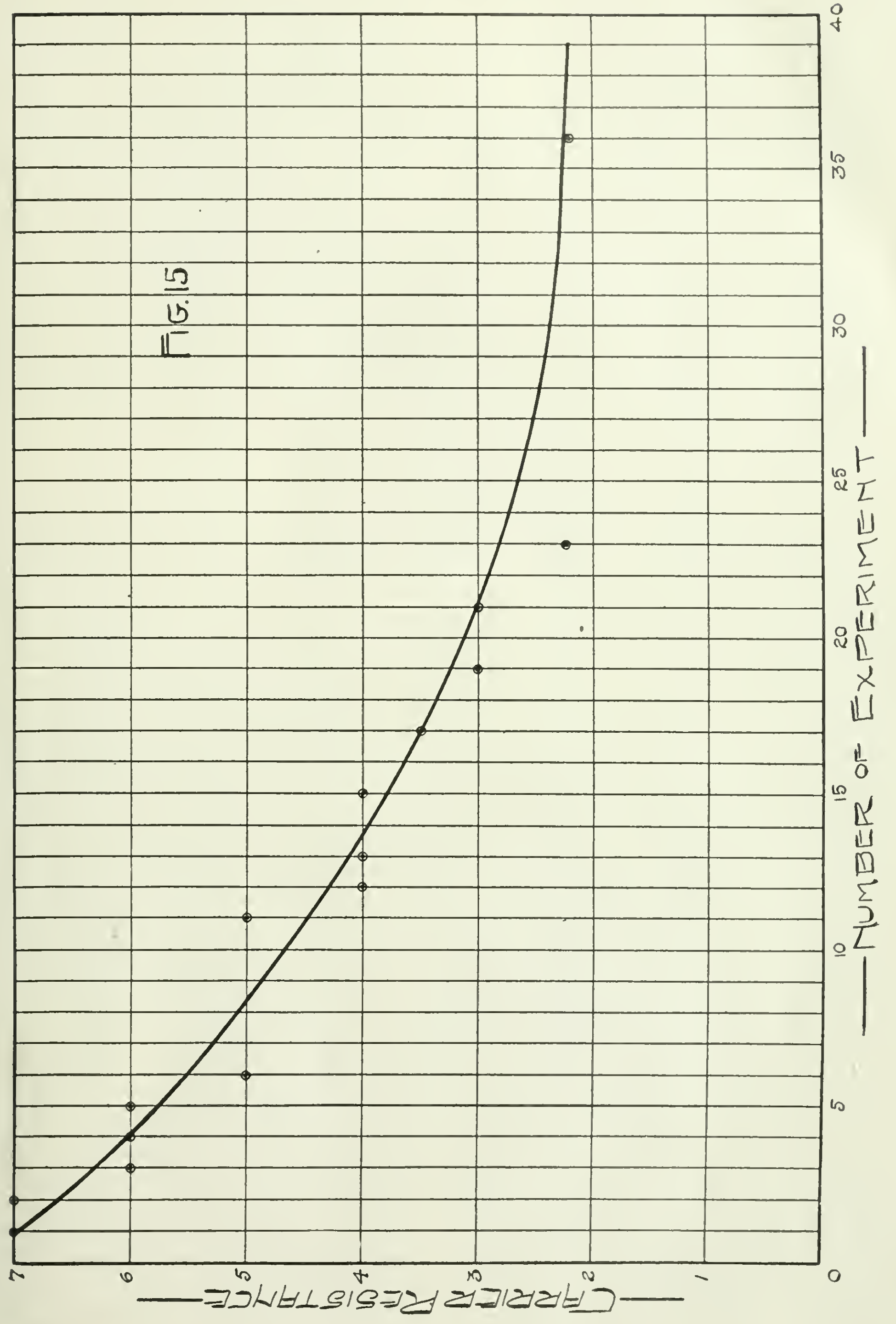
FIG. 15
NUMBER OF EXPERIMENT
0
5
10
15
20
25
30
35
40
CARRIER RESISTANCE
7
6
5
4
3
2
1
0

the carrier resistance expressed in inches of mercury per square inch.

Number of Experiment.	Resistance of the Carrier. Pounds.	Number of Experiment.	Resistance of the Carrier. Pounds.	Number of Experiment.	Resistance of the Carrier. Pounds.
1	7	6	5	17	3½
2	7	11	5	19	3
3	6	12	4	21	3
4	6	13	4	23	2¼
5	6	15	4	36	2¼

The range of the experiments was made as great as possible from the lowest to the highest practical carrier velocity.

The following tables contain a summary of the experiments:

EAST BOUND TUBE—July 9, 1901.

L=3882 feet. d=0.6778 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury. p_1	Mean Final Absolute Pressure. Inches of Mercury. p_2	Time of Transit. Seconds. t	Absolute Temperature. Fahrenheit. T	Coefficient of Friction. f Computed by (35)	Mean Carrier Velocity. Feet per Second. U_m
1	33.043	31.542	135.84	541.0	0.004599	28.578
3	32.546	31.294	146.63	541.1	0.004523	26.475
5	32.792	31.401	141.24	541.3	0.004638	27.485
7	32.678	31.353	143.37	541.2	0.004563	27.077
9	32.720	31.352	142.24	541.2	0.004628	27.292
11	32.614	31.306	145.88	541.2	0.004672	26.611
13	32.813	31.405	144.88	541.3	0.004938	26.795
15	31 747	30.889	178.52	541.3	0.004685	21.745
17	31.986	30.987	167.00*	541.3	0.004748	23.246
19	31.872	30.937	172.24	541.3	0.004739	22.539
21	31.868	30.938	174.25	541.3	0.004822	22.278
23	31.981	30.968	167.12	541.4	0.004826	23.229
25	36.313	33.221	92.65	541.4	0.004092	41.900
27	36.010	33 046	94.41	541.4	0.004102	41.118
29	36.066	33.101	94.66	541.5	0.004119	41.010
31	36.051	33.088	94.41	541.5	0.004096	41.118
33	39 602	34.972	77.08	541.6	0.003951	50.363
35	39 144	34.598	78.59	541.6	0.004079	49.396
37	39.914	35 081	76.08	541.6	0.003995	51.025
39	39.460	34.864	77.84	541.7	0.004014	49.872
41	44.774	37.733	64.53	542.0	0.003801	60.158
43	45.076	37 740	64.28	542.0	0.003913	60.392
45	46.007	38.340	62.77	542.2	0.003829	61.845
47	47.611	39.223	60.24	542.3	0.003746	64.442
49	47.894	39.470	60.00	542.3	0.003710	67.700
51	39.019	37.774	163.20	542.5	0.004644	23.787
53	38.413	39.936	146.63	542.3	0.004531	26.475
55	37.988	36.422	141.36	542.2	0.004481	27.581
57†	50.166	47.497	115.50	542.0	0.003916	33.610
59†	51.452	48.548	111.73	542.0	0.003894	34.745
61†	51.023	48.440	119.52	542.2	0.003987	32.480

*Time of transit, approximate.

†Valve at the open end of the tube was partially closed to increase the pressure throughout the tube.

The best measure of the precision of these experiments is the agreement of the results among themselves and the agreement of experiments made on different days. The experience of the earlier experiments was of great assistance in securing better results later, since it pointed to probable sources of errors and helped in the estimation of their magnitude. The precision of the pressure, time and temperature measurements is undoubtedly high and the dimensions of the tube are accurately known. The source of greatest error probably lies in the disturbing effect of the carrier resistance and escape of air past the carrier, but an effort was made to make errors from these sources inappreciable. In the case resistance of the carrier is greater than the amount allowed, the resulting value of ***f*** will be too large, and the escape of air past the carrier has the same effect. The method of correcting for the resistance of the carrier by subtracting the pressure necessary to move the carrier from the recorded initial pressure is not strictly correct, but the correction is so small that I believe the error of this method is negligible. No correction was made for the acceleration of the carrier. The size and length of the tubes in which these experiments were made give weight and value to them.

The values of ***f*** obtained from all of the foregoing experiments are plotted to a large

WEST BOUND TUBE—JULY 9, 1901.

$L=3884$ feet. $d=0.6778$ feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury. p_1	Mean Final Absolute Pressure. Inches of Mercury. p_2	Time of Transit. Seconds. t	Absolute Temperature. Fahrenheit. T	Coefficient of Friction. f Computed by (35)	Mean Carrier Velocity. Feet per Second U_m
2	31.257	30.043	145.13	541.4	0.004470	26.762
4	31.307	30.043	143.12	541.4	0.004522	27.138
6	31.331	30.046	142.11	541.4	0.004531	27.331
8	Record lost—	Carrier	lodged in	transmitter.		
10	31.286	30.053	144.63	541.4	0.004505	26.855
12	31.361	30.053	139.35	541.4	0.004434	27.872
14	31.368	30.052	139.36	541.4	0.004459	27.870
16	31.004	30.050	168.98	541.4	0.004782	22.985
18	30.974	30.048	169 23	541.4	0.004682	22.951
20	Record lost—	Carrier	lodged in	transmitter.		
22	30.896	30.043	179.00*	541.4	0.004807	21.698
24	31.000	30.045	168.00*	541.4	0.004732	23.119
26	33.120	30.141	90.14	541.3	0 004094	43.088
28	33.081	30.147	90.89	541.3	0.004102	42.733
30	32 962	30.142	92.90	541.3	0.004127	41.809
32	33.051	30.152	91.40	541.3	0.004101	42.495
34	34.636	30.208	74.57	541.3	0 004057	52.085
36	34.693	30.216	73.32	541.3	0.003961	52.973
38	34.913	30.227	71.56	541.3	0.003934	54.276
40	34.785	30.224	72.82	541.3	0.003974	53.337
42	37.746	30 343	57.50	541.3	0.003822	67.548
44	37.889	30.354	55.25	541.3	0.003583	70.299
46	38.565	30.373	53.98	541.3	0.003676	71.953
48	39.436	30.411	51.72	541.3	0.003663	75.097
50	39.296	30.408	51.98	541.3	0.003652	74.721
52	37.209	36.416	205.63	541.3	0.004880	18.889
54	36.752	35.715	179.78	541.3	0 004956	21.604
56	36.790	35.636	169.73	541.3	0.004921	22.878
58†	47.915	46.161	149.90	541.3	0.004488	25.911
60†	48.547	46.577	142.61	541.3	0.004513	27.235
62†	48.536	46.774	153.92	541.3	0.004693	25.234

*Time of Transit, approximate.
†Valve at the open end of the tube was partially closed to increase the pressure throughout the tube.

scale in Fig. 16, with mean velocities for abscissa to discover, if possible, whether or not *f* is a function of any other factor in the equation.

The most striking features of these results are the variation of *f* with the diameter of the tube and the apparent variation with the velocity. In view of the experiments of others, there can no longer be much doubt that the value of *f* does depend upon the diameter of the tube. For velocities about 51 or 52 ft. per second, Prof. Unwin's empirical formula fits the experimental values very closely.

In regard to the variation of *f* with the velocity, while it seems at first so apparent, I am not prepared to say that it has been demonstrated beyond all question, and the doubt will remain until these results are confirmed by other experiments, using some different method. It is possible that *f* varies not with the velocity, but with the density of the air. To throw some light on this suggestion, the experiments of July 9, numbering 57 to 62 inclusive, were made with the valve at the open end of the tube partially closed, which raised the pressure throughout the tube.

Experiments 57, 59 and 61 gave decidedly lower values for *f* than experiments at the same velocity, with less density. The same difference is not so marked in experiments 58, 60 and 62, with the best-bound tube. For the same velocity, the density of the air was always greater in the east than in the west bound tube, because it flowed first east and then west. If the value of *f* depends upon the density, we should not expect a curve of the experiments with the east-bound tube to coincide with a similar curve of the west-bound experiments, but there does not appear to be much difference—the results were about the same with either tube.

The apparent variation of *f* with the velocity may have been in part due to the disturbing effect of the carrier. The corrections of the initial pressures for carrier resistance were proportionately larger when the velocities were low. With a velocity of 20 ft. per second, a variation in the initial pressure of 0.01 inch of mercury makes a variation of 0.000065

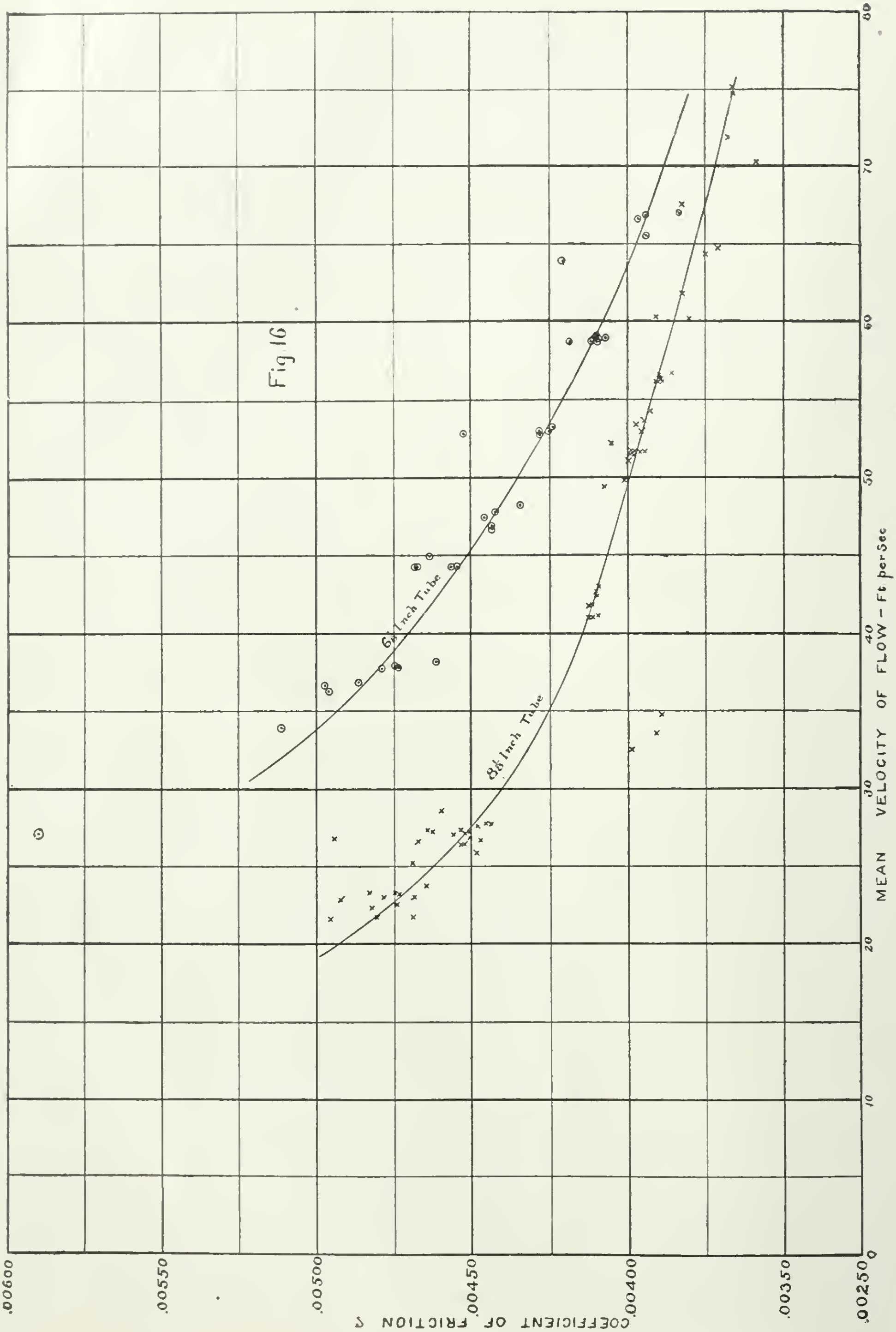
6⅛ Inch Tube
8⅛ Inch Tube
MEAN VELOCITY OF FLOW – Ft per Sec
0
10
20
30
40
50
60
70
80
COEFFICIENT OF FRICTION ζ
.00600
.00550
.00500
.00450
.00400
.00350
.00250

Fig 16

in *f* in the 6⅛-in. tube. I do not believe that errors from this source account for all the variations, for on July 9 the first and last experiments (exclusive of experiments with the valve at the end of the tube partially closed) were made with low velocities, purposely so arranged to detect, if possible, any effect due to the wear of the carrier. The carrier resistance had fallen from 7 to 2¼ lbs., and yet the resulting values of *f* are practically the same—the later experiments are a trifle higher in the west tube.

(*To be continued.*)

The seventh annual session of the Summer School for Artisans held under the direction of the College of Engineering of the University of Wisconsin begins June 24th, and continues for a period of six weeks.

Courses of study are offered in the following subjects:

1. Engines and Boilers.—Lectures and laboratory courses covering the theory, construction, management and testing of steam engines, boilers, gas engines and gas producers, refrigerating machines, etc.

2. Applied Electricity.—Lectures and laboratory courses covering the theory of direct and alternating current dynamos and motors, the operation and method of testing electrical machinery, batteries, transformers and other apparatus, photometry, and calibration of instruments.

3. Mechanical Drawing and Machine Design.—Elements of applied mathematics, courses in mechanical drawing and machine design adapted to the preparation of the students.

4. Materials of Construction, Fuels and Lubricants.—Lectures on the properties of materials accompanied by laboratory tests; lectures on fuels and lubricants with laboratory tests on the heating value of coals and efficiency of lubricants.

5. Shop Work.—Practice with hand tools, wood and metal working machinery, and in blacksmithing and pattern-making.

6. Manual Training.—Lectures and laboratory courses adapted to the requirements of manual training teachers.

The entire laboratory and shop equipment belonging to the College of Engineering is used by the students in the summer school.

The requirements for admission do not extend beyond a working knowledge of English and arithmetic, but the policy is to allow a large amount of individual work so that the student may take advantage of all the preparation he has obtained.

This school offers to those unable to take a regular year's course an opportunity of obtaining a working knowledge of the methods of testing and the use of instruments, together with such theoretical principles in each case as the nature of the subject and the preparation of the student may permit.

Correspondence students have found this school of value in giving an opportunity for laboratory practice along the lines in which they have had theoretical instruction.

A bulletin describing the work of the School for Artisans in detail will be sent on application to Frederick E. Turneaure, Dean, College of Engineering, Madison, Wis.

The value of the pneumatic machine is apparent to every man who walks the street beside a new building in course of construction and hears the rattle of the hammers and riveters driven by compressed air and beating an unceasing tattoo upon the iron beams and girders. It is said that pneumatic drills and riveters are all the make modern steel constructions possible. The bolts must be driven home and tapped while they are yet hot, and in the heavy materials used now in bridges and skyscrapers it would be impossible to do this work by hand.

In another machine of the automatic class which still is in process of development compressed air is used for the various parts of the machine in order to present the tools consecutively to the work and for the motions necessary for the cutting operations. The extreme lightness of air as compared with the mechanisms ordinarily employed for this purpose enables the "idle motions" to be made much more quickly than otherwise possible. Thus the time consumed in the withdrawal of one tool and the presentation of another is reduced greatly.

In Norwich, Conn., compressed air has very generally replaced beer pumps in saloons, clearing the barrels more effectually than by the old method and at a cost of but $2.00 per month tor each saloon.

THE COST OF A SMALL ROCK TUNNEL.*

Rock tunnels of small section are not frequently met with in the engineer's experience, and this fact probably accounts for the lack of data to be found in the text books and engineering periodicals on this subject. It pos- cost estimates and bid prices which have from sibly also accounts for the great variation in time to time come under the writer's observation; for unless an engineer has had actual experience in the construction of small tunnels, many of the items which go to make up their cost are either entirely overlooked or greatly underestimated.

Cost estimates for small tunnels are often based on the cost of running the heading in a large tunnel, which, of course, is perfectly correct in theory, but in practice usually results in an under-estimate of the cost of doing the work. This is brought about in the first place by the difficulty in separating the cost of heading from bench, as both classes of work are usually carried on at the same time, and in the second place by the fact that the volume of excavation in the bench is so much larger in quantity and cheaper in cost than the heading, that a slight error in distribution makes a large variation in the heading cost. Take for example the plant charges, depreciation, maintenance, etc.; this is usually divided by the total yardage of excavation, so that whether the excavation per day amounts to 100 cu. yds. for a large tunnel, or 10 cu. yds. for a small one, is of extreme importance.

The number of linear feet of hole drilled per cubic yard of rock is the determining feature of cost in all rock excavation, and when this runs from seven to ten linear feet of hole drilled per cubic yard in the heading, and perhaps but one or two feet per cubic yard in the bench, the wide difference in cost can be easily understood.

Powder is another large item of expense in small headings; to break out the first cut in a solid face of rock requires enormous force, quantities of dynamite. The writer has seen and this can only be obtained by using large as high as 9 lbs. of 60 per cent. dynamite used per cubic yard in hard rocks.

Another item which is generally over estimated is the average daily progress. Where it has been estimated that two shifts of drilling can be done a day, in practice it is often impossible to do so. The space for setting up the drills is extremely limited, so that the number of drills which can be economically worked is small, and if the rock is at all hard or seamy, ten hours is not more than enough to get the holes down. These holes have then to be loaded and fired and the tunnel cleared of fumes before the mucking gang can commence its work of clearing out sufficient loose material to set up the drill columns again.

There is still another item entering into the cost of small tunnels which is often lost sight of, and that is when the tunnel has to be lined with brick or concrete it is usually found uneconomical to do this work until the excavation has been completed. In other words, the space for tracks is limited, and it is apt to turn out that the interference of one class of work with the other is more costly than the delay of doing one class of work at a time.

There is usually a clause in the specifications which defines a circumference beyond which excevation will not be paid for, and in this lies another item of expense which the contractor's engineer is liable to under-estimate; for the smaller the tunnel the larger is the per cent. of circumference which will not be paid for per cubic yard of excavation. This excess yardage takes powder to loosen it and labor to remove it, and where it has to be replaced, as often happens, with concrete or rock paving without additional charges, the cost is often a heavy one. Twelve to 15 per cent. additional excavation beyond the neat excavation line in good firm rock has been met with.

The main items of expense in a small tunnel which came under the writer's experience were as follows:

The tunnel was about 3,000 ft. in length in hard trap rock, 9 ft. in diameter, and approximately circular in section running 2.46 cu. yds. of excavation per linear foot of tunnel. The air was piped to each end of the tunnel from a central plant, and both headings were run simultaneously. The plant consisted of two 75 H. P. Rand straight line compressors rated at 390 cu. ft. of free air per minute at 80 lbs.; three 100 H. P. locomotive boilers, together with air receiver, pumps, nine Rand Little Giant No. 3 drills, 20 tons, 12-lb. rails, and fittings, 5,000 ft. 4-in. wrought iron pipe and six 24-in. gage, ¾-yd. ore cars. A 10 H. P. Fairbanks Morse gasoline engine belted to 7 K.W. dynamos furnished light in the tunnel. Four drills were used at each heading and drilled in 10 hours 8 cut holes 7 ft. deep, 6 side holes 6 ft. deep and 3 top dry holes 6 ft. deep or 110 ft. The average cut pulled was 5 ft. or 12.3 cu. yds. at each heading. When the holes had been drilled the powder gang took down the column and drills, loaded and fired the holes; after which the mucking gang shoveled the loose rock into ¾ cu. yd. iron tunnel cars, which were drawn by a mule on a track made up of 12-lb. rails to the dump.

Figures 1 and 2 show the position and spacing of the holes in the tunnel. The eight center holes are the cut holes and are pointed slightly downward so as to hold water and at such angle with the direction of the tunnel that their far ends or bottoms come close together. The six side holes are also pointed

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*Francis L. Pruyn, Assoc. M. Am. Soc. C. E.

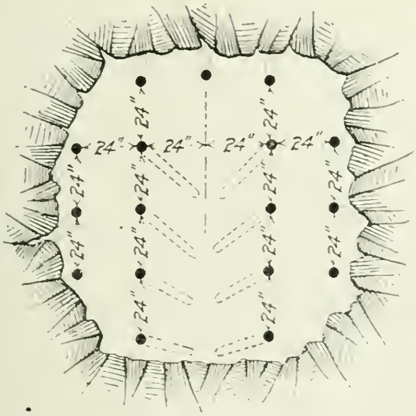

Fig. 1.

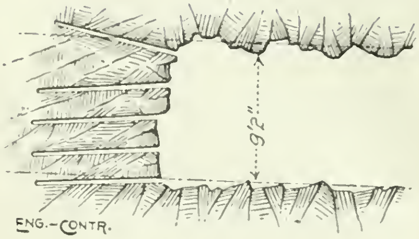

Fig. 2.

slightly downward and in such a way that their far ends extend outside the lines of the tunnel, so that the rock will break to proper line. The three top holes are dry and are pointed slightly upwards, so that their far ends will be a little above the grade of the roof.

The drilling shift started in at 7 A. M. and, on an average, it took 2½ hours to set up the columns and machines. They then drilled their heading and finished at 5 P. M.

The blasting gang then loaded and fired the holes so that the muck would be ready for the mucking gang which came on at 7 P. M. and worked until 5 A. M.

Seventy-five per cent. dynamite was used on this rock. It was seldom that the cut would pull clean to the bottom on the first shot and almost always an additional loading at the bottom of these holes was required before the full depth of the cut was reached.

The cost of the average labor force for the twenty hours during which time 10 lineal feet of tunnel at 2.46 cu. yd. per ft., were excavated, is shown to be equivalent to $23.02 per lin. ft. of tunnel.

The cost of the average labor force for 20 hours was as follows:

	Per day.	Per cu. yd.
Office:		
1 Superintendent at $250.00	$9.60	$0.39
1 Timekeeper at $65.00	2.50	0.10
Compressor:		
1 Compressor Engineer	5.00	0.20
2 Firemen	4.00	0.16
1 Electrician	4.00	0.16
Plant Labor:		
1 Master Mechanic	5.00	0.20
2 Pipe Fitters	6.00	0.24
2 Blacksmiths and Helpers	10.00	0.41
2 Walking Bosses at $5.00	10.00	0.41
8 Drill Runners and Helpers at $5.00	40.00	1.63
2 Nippers at $2.00	4.00	0.16
1 Blaster	5.00	0.20
2 Blaster Helpers at $2.00	4.00	0.16
2 Mules and Drivers at $4.50	9.00	0.37
12 Laborers at $1.50	18.00	0.73
2 Laborers' Foremen at $3.50	7.00	0.29
Total Labor	$143.10	$5.81
Insurance at 6 per cent.	8.58	0.35
	$151.68	
Powder, Exploders, Wire, etc., 8 lbs. per cu. yd. at 18.1 cts.	35.60	1.44
Coal, 4 tons, at $4.00	16.00	0.66
Gasoline for Lighting	2.88	0.12
Plant, including depreciation, repairs, drill steel, hose, etc., at $1 per cu. yd.	24.00	0.98
Total, 24.6 cu. yds. at $9.36 per cu. yd.	$230.16	$9.36

COMPRESSED AIR: ITS PRODUCTION AND USE.

English practice in the application of compressed air follows very closely the methods employed in this country, and the point of view taken by our cousins across the water is very interestingly presented by A. L. Daw of London, whose contribution to the literature on this subject is given in part.

HISTORICALLY CONSIDERED.

The use of air under pressure in the forge and in the reduction of metals from their ores has been known from the earliest ages, but its introduction to modern engineering seems to have been by Smeaton, in 1776, in diving bells for submarine work. Its first practical employment on a large and important scale was, however, by M. Sommelier, in 1860, at the Mont Cenis tunnel. From this its introduction into mining followed rapidly, as in all such operations it has especially great advantage over every other form of power, for, besides serving to transmit the required power, the exhaust air from the machines underground greatly aids the ventilation.

Recent years have marked an ever-extending use of compressed air for power transmission plants, and also for manufacturing purposes. Almost every modern engineering shop is now equipped with a compressed air power plant for the driving of all kinds of pneumatic, caulking, chipping and portable tools, riveting machines, traveling cranes and lifts, and in foundry work and numerous other appliances, and its use in almost every field of industry is daily spreading.

PRODUCTION.

Free air is drawn from the atmosphere into a cylinder, where it is compressed and discharged into a receiver for distribution through the mains to the points of application, and the efficiency of the process depends upon the passing of the *maximum* volume of air through the compressor cylinder for any given expenditure of power, and thus the construction and design of the compressor cylinder, its valves and piston are of the very first importance, as they are the primary instruments concerned.

CONDITIONS TO BE FULFILLED IN A PERFECT COMPRESSOR.

1. On the suction stroke the compressor should throughout the stroke fill with air at the exterior pressure.

2. The air should enter in a large stream with the least possible contact with the hot surface of the valves and cylinder that its temperature may be raised as little above the outside temperature as possible.

3. On the compression stroke there should be no loss of any portion of the contained air by reflux to the atmosphere by too late closing of the inlet valve, nor should there be any leakage back, but the whole contents of the cylinder, less the minimum of clearance, should be discharged through the outlet valve.

4. The outlet or discharge valve should have ample area of opening, should open automatically on the pressure in the receiver being reached in the compression cylinder, and the air should be discharged at a pressure as little above that in the receiver as possible, as excess pressure causes a rise in temperature with increase in volume, requiring a corresponding increase in the work necessary to compress and discharge the air.

5. The discharge valve should have sufficient width of seating to insure its keeping quite tight that no loss by leakage back into the cylinder may take place.

6. The valves should be self-adjusting under all speeds and pressures.

7. Full volumetric efficiency.

8. All the valves and the piston should be easily accessible for examination and renewal.

9. Wear and tear should be reduced to a minimum.

It will be evident from the above that the construction of an air compressor is a very different problem than the mere building of an air pump, and that it calls for a full technical knowledge, combined with practical experience in the building and use of such machines.

COMPRESSOR VALVE SYSTEMS.

An examination into the construction of air compressors will show that they may be broadly classed as below, according to the manner in which their inlet and discharge valves are actuated.

1. In which poppet valves are used for both the inlet and discharge of the air, arranged.
    - (*a*) In the cylinder covers.
    - (*b*) Partly in the cylinder covers and partly in the cylinder walls.
    - (*c*) With inlet valves in the piston and with discharge valves either in the cylinder covers or walls.
2. With large hinged flap valves arranged

in the cylinder covers and actuated similarly to poppet valves.

3. With mechanically operated inlet and discharge valves which open and close gradually through direct mechanical connections.

4. With inlet valves mechanically operated and with poppet discharge valves.

Poppet valves require to be small in diameter and light in weight, and to have a small lift to prevent hammering. The valve area is in consequence necessarily restricted to the minimum, and a common defect is insufficient space for the inlet of the air and for its proper discharge after compression. As poppet valves have no tendency to close by themselves, they require strong springs to insure their proper action, and therefore the cylinders to which they are fitted *never* can fill to the full exterior pressure because, as is evident, to open and keep open the valves there must always be such difference between the inside and outside pressure as is necessary to overcome the resistance of the spring, and the result of this is loss of power. This loss of power is further increased by the air being unnecessarily heated by coming in contact with the hot surface of the valves and seatings through being drawn in in a thin stream, and more especially is this the case when the inlet valves are placed in the piston, as then the air comes in contact with the hot piston and also of necessity with a long hot admission tube.

Large hinged flap valves arranged in the cylinder covers have the advantage over poppet valves of larger valve area, but require heavy springs to close them, and as with poppet valves the cylinder in consequence never can fill with air at the exterior pressure for reasons given above. Further, the large size of the valves necessitates an elaborate arrangement of spring frictional and other buffers which limit the speed and output of the compressor.

With valves operated through direct mechanical connections there are many difficulties in the way of positive movement, and especially of such movement in the discharge valves, as the point of discharge varies with the pressure, and this is effected more or less by the conditions of temperature, density and moisture of the inlet air, and the cooling effect during compression. The discharge valve should open when the pressure in the receiver has been reached in the cylinder if loss of work is to be avoided, and equally serious in loss of efficiency would it be to open a discharge valve before the receiver pressure has been reached in the cylinder. A further grave defect with many mechanically operated valves is that the discharge opening is closed gradually toward end of stroke, compelling, by great rise in pressure, the last portions of air to pass the valve at excessive speeds with rapid rise in temperature much beyond the temperature of discharge, with attendant danger of explosion should there be an excess of lubricant or should a lubricant of inferior quality be used.

The ever-varying conditions make the operation of compressor valves mechanically so unsatisfactory in practice.

TRANSMISSION.

The transmission of power, to a greater or less distance, is a problem that frequently engages the serious consideration of the engineer. The means at his disposal are steam, water, wire rope, electricity and compressed air, and the advantages of each of these systems vary with the conditions attending their application.

Of the first three the merits and limitations are too familiar to require enumeration, and the choice is limited to electricity or compressed air when the distance of transmission exceeds a limited range.

The applications of electrical energy to industrial uses have received so much attention at the hands of scientists, engineers and capitalists, that the greater economy and suitability of compressed air to many of these uses have been thereby forced into the background and neglected. Further, experience has shown that the high efficiencies first claimed for electricity have failed to be verified, and the rapid strides made in the production of compressed air with the greater knowledge gained in its transmission and use is directing more and more attention to this somewhat neglected force as a means of power transmission.

With electricity the cost of the wire governs the voltage, which, when the power has to be transmitted a distance, varies between 2,000 and 50,000 volts, if the cost of the wire is to be kept within reasonable limits. The voltage or electric pressure after transmission has to be brought down to the proper limits for safe distribution and use, necessitating the employment of step-up and step-down transformers. There are the following stages in the production and use of electric power in distance transmission:—

1. The engine or motor.

2. The dynamo
3. The step-up transformer.
4. The cable transmitting the power.
5. The step-down transformer.
6. The cable distributing the power.
7. The electric motor developing the power after its transmission.

And, although the efficiency of the modern dynamo is a triumph to the skill of the electrical engineer, the power, as seen above, is transformed so many times between the generating station and point of application that, notwithstanding the high efficiency of the dynamo, the efficiency of the whole system is probably not greater than 50 per cent.

Further, the electrical apparatus, with its multiplicity of transformers, high potential insulators, and other high potential devices, is exceedingly liable to break downs and necessitates constant supervision by skilled men.

In power transmission by compressed air there are the following stages:

1. The compressor.
2. The pipe line.
3. The motors.
4. The re-heater for re-heating the air before admission to the motors if the fullest economy of the system is to be utilized. Without re-heating the efficiency of the system should be 45 per cent., and with re-heating from 55 per cent. to 60 per cent.

The first point to be decided by the engineer is the pressure at which the air shall be transmitted, as this governs the type of compressor and the size and cost of the pipe line. For long distance transmission the power can be commercially most economically transmitted at high pressure of from 120 to 150 lbs. per square inch, the pressure being reduced at the point of distribution in accordance with requirements.

The next point to be determined will be the pipes to be employed, in which the considerations of most importance are the material, diameter and character of the joints.

With regard to the motors, these of course are governed by the pressure at which the air is to be used and the work to be done.

As to the re-heating of the compressed air after transmission and before admission to the motors, users generally have as yet failed to recognize the importance thereof, although a large increase in efficiency is thereby obtainable, and any practical difficulty due to the cooling of the air in expansion in the motor entirely obviated. Air at 32 deg. Fahr. expands on heating 1/461 part of its volume for each degree Fahrenheit, and thus the re-heating of the compressed air before use in the motor is of the greatest commercial importance, as less air is required per stroke of the motor. The economy gained will, of course, depend on the relation between the additional work obtained and the fuel expended. Experience shows that the heat supplied is used with great efficiency, and that by heating the air before use the work done per pound of air may be increased from 25 to 40 per cent.

A further point of great advantage in the adoption of power transmission by compressed air is that the compressor, pipe line and motors are all easily understood and operated by mechanics accustomed to the use of ordinary steam engines, and thus the necessity for specially trained skilled men is obviated.

BOBBINITE THE LATEST COAL-GETTING EXPLOSIVE

There is no such thing as a completely safe explosive—that is to say, there is no explosive known which, under any conceivable circumstances, might not ignite gas or dust, or a mixture of gas and dust. But the relative safety of the very best and highest class of explosives, as compared with gunpowder, is so great that the difference of safety in degree practically becomes a difference in kind.

Bobbinite is classed as a non-detonating mechanical mixture which consists of a high-grade gunpowder containing but little sulphur, mixed with starch and paraffin-wax, and compressed into a pellet coated with paraffin-wax. It was tested in various ways, and practical experiments were conducted with it in four seams of widely varying character, when it produced marked advantages in coal-getting over other substances of a similar type. It is the opinion, however, that the experiments indicated that Bobbinite and several other explosives of this character, where insufficiently confined, are more likely to explode gas than those explosives which give a high "charge limite" when tested without stemming. The "charge limite" is defined as the maximum charge which, in a series of ten shots fired unstemmed from a gun, fails to ignite an explosive mixture of gas and air in an experimental gallery.

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AT GREAT DEPTHS WITH COMPRESSED AIR

The remarkable success which engineers have made in driving tunnels under rivers and other important waterways in various parts of the world, has led to a serious consideration of employing similar methods for establishing subaqueous passages beneath straits, bays and even the ocean itself. From the constructional point of view, there is not the slightest doubt of its feasibility for what has been done so satisfactorily in many cases can be extended to a far greater degree.

At the present time financial reasons would alone seem to prevent the boring of tunnels between Europe and Africa, or Asia and North America, since the expense would be, perhaps, larger than the ultimate advantages to be secured. Furthermore, in the face of the diplomatic relations existing between world powers such engineering feats appear to be well-nigh impossible. However, apart from this, engineers regard with confidence the proposition of sub-ocean tunneling because the achievements already attained have been due to the development of the compressed air system. At first, when this system was introduced, its possibilities were only conjectural, for its beginnings were small inasmuch as it was used for driving bores, making foundations for bridges and wharves under river beds and in water-bearing strata generally. But it has developed steadily, until now work is carried on with safety and with certainty as regards its final result, at depths up to nearly 120 ft. below high-water level, involving an air pressure of 40 lbs. per square inch above the atmosphere. In fact, in nearly every instance, where water is likely to be encountered, compressed air is now adopted, for engineers prefer to use it as a safeguard against any emergency. Whether compressed air can be applied for deep-sea boring is still largely a matter of experiment. Still, the shield system has operated so accurately in all cases with such practical results, that its application to engineering problems of such magnitude as referred to above, is highly probable.

CASTING AIR COMPRESSOR CYLINDERS

Cylinders of air compressors, gas engines, and some steam engines are often exceedingly intricate in design; due in the case of the two former, to the presence of the water jacket, while in high-grade steam engines a steam jacket is often provided. Where these cylinders are cast in one piece, it is obvious that great care must be exercised to eliminate flaws, and even when cylinder liners are used, the process is a most important one. There has lately been manifested considerable interest in processes that will insure better castings, by introducing small quantities of titanium into the molten metal just before pouring, thus purifying it, and increasing its fluidity, making the pouring of complicated and intricate castings a less difficult operation. Readers of COMPRESSED AIR will probably be interested in knowing of an easy method of accomplishing these results. In fact, the process is so simple that it is within the reach of all who desire to increase the quality of their product. It consists of introducing a specially prepared can of titanium Thermit into the ladle and allowing it to burn while at a point near the bottom.

To those who are not familiar with the composition of Thermit it might be well to state that it is a mixture of finely divided aluminum and iron oxide, which, upon ignition reacts to form aluminum oxide and pure molten iron or steel (according to the quantity of carbon introduced) at a temperature of 5400 deg. Fahr. Titanium Thermit is a mixture of ordinary Thermit and titanium oxide, which reacts to form liquid iron and metallic titanium, as aluminum unites equally well with the oxygen of the titanium oxide as it does with the iron oxide.

Titanium has a great purifying effect on molten iron, as it combines with the nitrogen in the liquid, forming cyanonitride of titanium. By this reaction, in conjunction with the heat of the Thermit reaction, a strong seething motion will be produced throughout the entire mass of the metal. Gases will be driven out and the liquid will show a white color almost as of steel, proof of its high temperature and fluidity. On analysis, however, the cast iron will not show any traces of titanium, other than what is in excess of the contents of the nitrogen.

The process is particularly valuable in the pouring of castings requiring a smooth finish, or that will be subjected to high pressures and great friction. In fact, it will be found that parts cast from this purified metal will possess an increased strength of at least 10 per cent. and will be of very fine grain.

It should be evident that the process is especially applicable to the casting of cylinders for air compressors, gas engines, steam engines, ammonia compressors, and hydraulic fittings of every kind, where strength, durability and high finish are required.

CARE OF AIR COMPRESSORS.

Valves which stick can often be successfully lubricated and kept in good condition by use of a little kerosene oil, applied with the usual machinery oil can.—*Mining & Scientific Press.*

We quote the above paragraph to show how some people may be misled regarding the handling and care of air compressors, and because we believe that such articles as the above are often responsible for serious accidents. Kerosene oil ought never to be used in this way, and if used at all on the air cylinder, great care should be taken to remove all of it before starting up the compressor. A much better and safer way of cleaning the cylinder and valves is to feed ordinary soapsuds through the cylinders for several hours every week or two. It may be passed through the lubricator instead of oil, but care should be taken to run with oil for a while after its use, before shutting down, in order to prevent rusting.

It is a very good practice to keep an extra set of outlet valves on hand, as this enables the engineer, at any time, to replace those on the compressor with clean ones. The change may be accomplished in a very few minutes and the dirty valves may be thoroughly cleaned by the engineer at his leisure.

COMPRESSED air seems likely to be used more extensively as machine tools are developed. The rapidity and facility with which it can be conveyed and its small mass make it well adapted for use in metal working machinery. In fact, its extreme rapidity needs to be checked in some instances where uniformity of motion is required under varying resistance, and this check is applied by the use of a body of water or oil, which is forced by the air pressure through a restricted but usually adjustable opening, and in turn acts upon the mechanism to be moved. The liquid, by resisting sudden changes in its rate of flow, regulates the speed of the motion.

A class of machines originally designed for making screws, but more recently employed also in making numerous small parts of machines and other articles, and known to the trade as "automatics," has been developed largely during the last five years.

At first these automatic machines would handle stock up to one inch in diameter only, and were used almost exclusively for making screws. They are made now to handle steel bars up to six inches in diameter, and are used for an almost endless variety of small parts. Many of these machines have a magazine attachment, by means of which castings or small forgings are fed successively to the machines. They require no attention whatever except to keep the magazine supplied with material and the various cutting tools sharp and properly adjusted.

A practical milking machine has been installed on the dairy farm of C. F. Moulton & Son at Cuba, N. Y., where 24 cows are now successfully milked twice each day by the new apparatus. A combination of the vacuum and compressed air systems is use
the vacuum and compressed air systems is used.

NEW PUBLICATIONS.

The newest contribution to cement literature, and one for which there has been a demand for a long time, is "Concrete Factories," a series of papers descriptive of the uses of cement and concrete as applied in the construction of industrial plants. This book, which contains 152 pages, is compiled by Robert W. Lesley, associate American Society of Civil Engineers, and the editor of *Cement Age,* and is published by Bruce & Banning, 1 Madison avenue, New York.

This book offers in condensed form the most complete review of the principles underlying reinforced concrete construction that has yet been published, and has the still further advantage of being understood by the layman as well as the engineer. The book contains the report of the United States Advisory Board on fuels and structural materials, the report of the sub-committee on tests, the only translation of the French rules on reinforced concrete—which have just been issued by the Ministry of Public Works in France—and a number of profusely illustrated articles showing well-known reinforcing systems.

"Reinforced Concrete Construction," a chapter by Walter Mueller, is perhaps the most concise description that has yet appeared on the many concrete reinforcing systems now in the market, and "Concrete in Factory Construction," by E. A. Trego, reviews the work that has been done with concrete in the construction of industrial plants during the past few years.

"Concrete Factories" also contains "A Surface Finish for Concrete," by Henry H. Quimby, American Society of Civil Engineers, and a symposium of articles on the use of concrete in constructional work by Emile G. Perrot, C. A. P. Turner, E. P. Goodrich, J. R. Worcester, Dean & Main, Leonard C. Mason, E. S. Larned, Chester J. Hogue, J. G. Ellendt, and A. E. Lindau, and other eminent authorities on concrete construction work.

TRADE LITERATURE.

Latta & Martin Pump Company, Hickory, N. C.—A brochure, 20 pages, 11x8, describing in full the operation of their pneumatic displacement pumps, especially designed for manufacturing plants, mines and all centers where it is necessary to secure water quickly. Also there is a specially designed air lift showing its utility and the limitations for deep-well pumping. Included in this publication is a brief article on compressed air versus the steam pump.

G. L. Stuebner Iron Works, Lone Island, City, N. Y.—Catalog No. 50, 12 pages, 4x9, which deals exclusively with the Excelsior Bottom Dumping Buckets, which are particularly adapted to handle concrete, mud, sand, rock, etc. One of the chief features of these buckets is the locking device which holds the bottom in place and the operating mechanism is simple in design and extremely rapid.

Jersey City Crucible Company, Jersey City, N. J.—Booklet entitled, "A Study in Graphite," by Prof. W. F. M. Goss of Purdue University, 43 pages, 6x9, appealing particularly to those interested in short-cut methods of lubrication. This pamphlet covers in detail a series of tests of graphite not made with any special design to finding points for or against this material, but conducted in the spirit of scientific research. This study in graphite opens with an essay by Prof. Goss, based upon the conclusions drawn from the test. Complete descriptions of these are made, together with a number of illustrations of the testing machine. A summary of results obtained is shown in several tables, which are particularly valuable.

W. G. Leale Company, San Franicsco, Cal.—Pamphlet, 36 pages, 4x9, known as the Starrett System of Pumping by Compressed Air, covering a new process of pumping adapted for mining, windmills, irrigation, and high oil wells. Reference is made to their efficiency in high-duty plants and the illustrations prove their practical effectiveness.

Fairbanks Morse & Company, Chicago, Ill.—Profusely illustrated pamphlet entitled, "Practical Irrigation," 36 pages, 6x9, dealing thoroughly with mechanical irrigation problems and containing much pertinent data with reference to many different types of pumping machinery used for this purpose. The illustrations show the irrigating plants in actual operation, these installations covering a wide range of service, including pumps operated by gasoline, steam, electricity and the wind.

Webster Manufalturing Company, Chicago, Ill.—General catalog No. 30, 573 pages, bound in cloth, 6½x9¼, giving full and detailed information concerning the elevating, conveying and power-transmitting machinery manufactured by this company. This book is superbly printed and illustrated, giving price lists of every sort and kind; also the machines and their parts. It is a useful compendium to which reference can be made by superintendents and managers of large manufacturing plants and power stations when new installations are being considered.

Robins Conveying Belt Company, 13 Park Row, New York.—Four-page leaflet, describing the installation of a package conveyor system in the new store of B. Altman & Co., Fifth avenue, New York. This circular is illustrated with cuts showing the working qualities of the belt and the central discharging point where the packages are received prior to their being placed in the delivery wagon. There are three conveying belts, 30 in. in width, 71, 91, 191 ft. in length, which operate on a series of idlers; also there is one large flat belt 36 ins. wide and 75 ft. long, guarded at the sides, being designed especially for the conveyance of unwrapped packages. These belts are entirely noiseless in operation, being so constructed that they perform the work quickly and efficiently with a minimum amount of friction.

CORRESPONDENCE.

To the Editor of Compresser Air:

Dear Sir—We have recently subscribed for your magazine, and you kindly favored us with some back numbers. We find in the April, 1906, number a picture of a portable electric motor for cylinder boring. We have lately been doing the same thing with the real thing, which is compressed air.

A cylinder of a locomotive on the P. and L. R. R. had the port so broken in that the only remedy was to put in a liner. We had it run on our siding and piped air about 600 feet to it, using a small steam engine which we ordinarily use for driving our boring bars with steam wher it is available. We bored out the cylinder, then inserted the lining and bored it in place, and the engine is now in service.

We enclose you a photograph we had made, showing the operation; and also a photograph of our works, which shows the location of the locomotive while the work was being done. The compressor is located in the building which has the taller of the two square chimneys, and is at the right of this chimney. You can see the pipe along the end of the brick building next the locomotive. This work was done in zero weather, and we were surprised at not having more trouble with the condensation freezing, but it gave us no trouble whatever. Yours truly,

Poughkeepsie Foundry and Machine Co.
H. M. Bullard, General Manager.

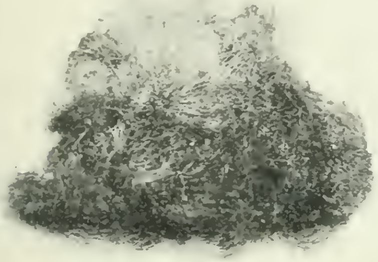
INDUSTRIAL.

NEW EARTHQUAKE RESISTER.

The San Francisco disaster has just had its first anniversary. Some of the lessons are still fresh in the minds of those interested in municipalities. Careful men have personally inspected the ruins and made suggestions to architects, builders and engineers, based upon the data obtained during the inspection. But there is one field which has not been covered, and one danger that has not been brought as forcibly to the minds of municipal engineers as its importance would warrant. And, strange as it may seem, this very one was responsible for more damage than the earthquake itself.

It will be remembered that San Francisco burned owing to lack of water, the water-pipes being disrupted during the earthquake. Has the question been sufficiently agitated, with a view to preventing such a cumulative disaster in the future? Have we any method of joining water pipes, so that a vibration, or a settling of the ground, will not strike paralysis to an entire city's fire protection?

This paper is glad to recognize any efforts which seem to point in the right direction, and which tend to lessen the risk from such causes.



Shredded Lead.

A new substance is just being put upon the market by the United Lead Company, of 100 William street, New York, known as shredded lead, which is caulked into the joints in a manner quite similar to the caulking of the yarn in a stuffing box, but which has such a consistency as to make a perfectly tight, yet flexible joint, we are told. If such a thing can be made commercially practicable, the old method of pouring melted lead into the joint will soon become a thing of the past, as the shrinkage of the metal upon cooling materially weakens the joint and renders it subject to leaks upon the slightest provocation.

THE Consolidated Equipment Co., of 17 Battery place, New York city, have been appointed selling agents for the Emerson pump. This company's well-known triple vertical cylinder contractor's pump will be supplemented by a new product—the Emerson Junior. This latter is made with but a single cylinder, weighs but 219 lbs., and has a capacity of 100 gallons per minute against a 25-foot head, and about half this capacity on a 100-foot head. A stock of regular and Junior Emerson pumps will be kept on hand in New York and at the factory in Alexandria, Va., which is to be enlarged to accommodate this new design.

PURCHASING agents and those responsible for the materials which enter into the construction of cars, which will render the rolling stock immune from fire, are intensely interested in "Kantlite," a specially treated substance, of which Wendell and McDuffie, 26 Cortlandt street, New York, are the sole selling agents.

"Kantlite" is a fibre board which to make fireproof is subjected to chemical treatment both in its raw state and also during the process of manufacture. It can be stained the same as wood veneer and at the same cost, having approximately 80 per cent. of the strength and 85 to 90 per cent. of the weight of oak.

THE Hancock Consolidated Copper Co., Mr. John L. Harris, superintendent, whose mines are located at Hancock, Mich., has recently ordered from the Sullivan Machinery Co. of Chicago a hoisting engine to be used for sinking the principal shaft and for permanent service, after the shaft is completed to its final depth of 4,000 feet.

This hoist will be of the first motion, heavy duty, Corliss type, with engines 24-inch diameter by 48-inch stroke, and two loose drums, 8 ft. in diameter by 9 ft. long, driven by band friction clutches, and designed for hoisting in balance. The drums will be grooved for 1¼-in steel rope, and the maximum hoisting speed under full load will be 3,500 ft. per

The clutches and band brakes will be steam operated, with automatic compressed air substitution in case the steam pressure falls below a given point, owing to accident or for other reasons.

TWO drops of ammonia on a lump of sugar eaten immediately is considered a fair antidote for internal cyanide poisoning. This is usually the treatment when peroxide of hydrogen cannot be obtained promptly. In cases of external cyanide poisoning a warm bath containing bicarbonate of soda and common salt will allay the eruption.

In the cylinders of a compressed-air locomotive, only a low cold-test oil should be used. The oil should show a gravity of about 29, and a cold test of—5 deg. Fahrenheit.

CHIPPINGS.

COST OF PUMPING WITH THE AIR LIFT.

This question is usually asked without giving several items which largely determine the answer. Thus, coal at $2 is one thing, at $4 another. Again, some wells are nearby and in other plants the pipe investment is greater because of scattered wells. Speaking generally, the average cost per thousand gallons pumped depends on the size of plant and height of lift. In a 4,000,000-gal. plant, with a 50-ft. lift, it is about ⅓c. per 1,000 gal. In a larger plant, with a 35-ft. lift, with coal at $2, it is about 1½ mills. In another case, where the lift is 75 ft. and the capacity 1⅓ million gal., the cost is 1c. per 1,000 gal., coal costing $2. In a plant pumping 3,000,000 gal. 75 ft. high, the cost is 4.5c., and where the lift is 50 ft. 3.5c. In Pennsylvania, a plant giving 175 gal. per minute at 75-ft. lift, costs 1⅓c. per 1,000 gal. In a proposed municipal plant 100,000,000 gal. per 24 hours, 50-ft. lift, and with coal at $1.50 a ton, the cost figured 1 mill per 1,000 gal., including all fixed and operating expenses. In another case, involving the handling of about 15,000,000 gal. of water 30 ft. high every 24 hours, using compound condensing compressors, and with coal at $2 per ton, other figures being estimated on a very generous basis, the cost nets about $2.50 per 1,000,000 gal., or about 2½ mills per 1,000 gal. These figures cover fuel, oil, labor, sinking fund, interest and taxes.

In many cases the introduction of the air lift may be effected at little expense, often involving the purchase only of an air compressor, a receiver, and a small amount of pipe, but the following is estimated on a basis which will cover the greatest amount of expense likely to be incurred, with a view of showing particularly that the interest and depreciation charges under the most extreme conditions are not likely to develop into formidable figures. The following is a list of the complete equipment for an air lift plant to raise 1,500,000 gal. per 20 hours, or 1,250 gal. per minute. Total lift, 75 ft.: Air compressor, complete, ready for foundation and piping. Air receiver. Boiler, 85 h.p., with feed pumps, etc., bricked up and ready for use, including building and value of ground so occupied. Tank, 19,000 gal. capacity, including suitable timber framework to bring tank 75 ft. above water level. Two 12-in. wells, each 135 ft. deep, cased. Casing, 450 ft. 7⅝ in. light pipe. Air pipe, 500 ft. of 3-in., air pipe in wells. Air pipe, 1,000 ft. of 4-in. air line from receiver to wells. Water pipe, 1,250 ft. of 12 10 and 8-in. cast-iron distributing main, leaded joints, from tank to works, laid below frost (air line laid in same trench). All other pipe and fittings. Compressor, receiver and tank foundations, laid in cement. Special automatic governing mechanism. Total estimated cost of complete plant, ready to run, as above, $8,750. This is intended to include everything which may be considered as a legitimate expense in this connection. In many cases the buildings, boilers, tanks, wells, pipe lines, ground space, and other items do not represent a present expense, being already on the ground.

We may estimate the cost of operation as follows: Engineer, double shift, at $2.25 per day, $4.50, ⅕ time chargeable to pumping plant, per day, $0.90; Fireman, double shift, at $1.75 per day, $3.50, on the basis of one man required for each 250 h.p. of boiler for 85 h.p. per day, $1.19; fuel, 85 h.p., 20 hours, say 4¼ tons, at $2 per ton, per day, $8.50; oil, waste and sundries, say, 60 cents; interest on investment of $8,750 at 5 per cent., figuring eleven 25-day months, or 275 working days per year, per day, $1.91; deterioration, covering sinking fund, repairs, etc., providing for renewal of complete plant every ten years same basis as interest but 10 per cent., per day, $3.18; insurance and taxes at 1 per cent., as above, per day, 32 cents; total estimate cost of pumping 1,500,000 gal. per day, 75 ft. high, under the above conditions, $16.60. Cost of each 1,000 gal. ($16.60 ÷ 1,500) = $0.01107.—*The Engineering Record.*

TO one who has followed the recent developments in mining machinery it is evident that the air hammer rock drill marks as important a step in progress as any since the introduction of power-driven drills. The air hammer drill is cheap, wonderfully efficient, economical to operate and is adapted to a variety of uses. As a measure of utility, it can be said that nearly every one of the half doen or more manufacturers of these machines is working full capacity to meet the demand of the mining industry.

LIMITS TO LOSSES IN COMPRESSED AIR SERVICE

We hear certainly enough, and probably too much, of the power losses which inevitably accompany the employment of compressed air as a transmitting and operating medium. We certainly do not hear enough of, and do not sufficiently bear in mind, the fact that whatever these losses may be there is always a limit to them which can not well be exceeded. Steam losses seem to be without limit.

In the development of power by means of steam the coal-cost per horse-power hour in steam-operated apparatus in actual use ranges from below 2 lbs. to above 40 lbs. There is no loss in compressed air practice comparable with this. In the compression of air to, say, six atmospheres, a very common working pressure the power cost by adiabatic—the most costly—compression exceeds the cost by the ideal and practically impossible isothermal compression by only 32 per cent., and there is no discoverable way of making the cost of air compression any greater. The air compressors in use a score of years ago were crude and wasteful as compared with those which may be considered standard to-day. In the improvements which have been made in steam-driven air compressors the power savings effected have been much greater at the steam ends than at the air ends.

But it is rather in the employment of the air after compression that the limitation of losses most asserts itself. The unceasing condensation and disappearance of steam, beginning immediately upon leaving the boiler and continuing uninterruptedly after leaving belongs to steam alone; air has no corresponding or comparable loss. The volume of air delivered by the compressor decreases somewhat with its fall in temperature, but when normal temperature is reached shrinkage ceases and this loss ends. The water of condensation is another thing to be reckoned with in the use of steam, and also the delay and the steam-cost of heating up the steam-operated machine every time it is operated, with neither of which conditions does the air have anything to do. Compressed air seems to be unique among power transmitters in that it is always ready to do its full work and yet charges nothing for its time while standing waiting.

The beginning of the employment of compressed air for driving rock drills in mines and tunnels was enforced by other considerations than these, but mines and tunnels are not now the largest employers of compressed air. It is no wonder that we find it making its way for work in the open, that many quarries are operated by it exclusively, that such undertakings as the enormous excavations in New York for the new stations of the Pennsylvania and the New York Central Railroads should each depend upon the air compressor to do the most of the work. Most of the air in these cases is not transmitted more than the length of half a dozen city blocks; where the distances are greater the advantages of air power transmission becomes more pronounced, and so it is entirely in line with the most advanced engineering practice that air compressors are finding employment upon the Panama Canal. When we hear of many more compressors being installed upon the job we may find therein increased encouragement to hope for the ultimate successful completion of the work.

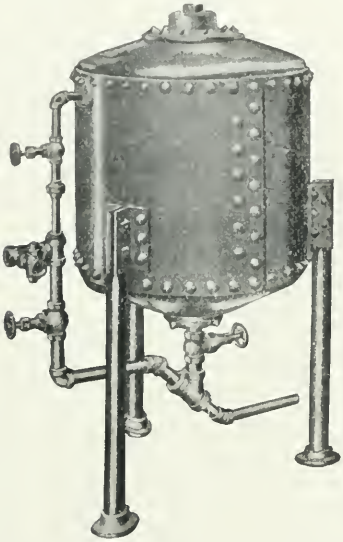
Notwithstanding the many great engineering works in progress and the number of air compressors employed upon them, there seems to be little danger of their working themselves out of a job. Their work grows upon them and one thing follows another. Two of the largest of the 100 compressors now employed upon railroad and tunnel work in or immediately in touch with New York City were previously used on the excavation work for the works, another in open-air operation.—*Cassier's Magazine.*

Compressed air locomotives, which in the past few years have come into extensive use for mine haulage, work under pressures ranging from 500 to 2,000 lbs. per square inch. The pressure is determined mainly by the size of the locomotive permitted by the dimensions of the tunnels and curves. In tunnels of good size the large reservoirs required by low pressure engines are permissible, but where only small reservoirs can be used it is necessary in order to carry the supply of power required to compress the air to a higher degree in the steel tubes (bottles, as they are sometimes called), which are made of such a strength as to safely carry the pressure.—*Iron Age.*

COMPARISON BETWEEN THE HIGH PRESSURE SAND BLAST AND THE LOW PRESSURE MACHINES

The difference between high pressure sand blast and low pressure machines, says the *Boiler Maker,* depends upon a principle which is distinctly radical.

The principle on which, up to date, the different blasts have been working was, to use low pressure (15 to 30 lbs.) and a large nozzle. These machines use anywhere from 60 to 490 cu. ft. of free air per minute, with ⅜-in. to ⅞-in. nozzles.



It will be seen from the following that in order to work such blasts economically, it is necessary to install, in addition to the regular shop compressor (carrying from 80 to 100 lbs. air pressure), for these blasts an extra compressor working under low pressure. The idea of taking the air from the regular shop system and reducing it by a reducing valve to 15 or 30 lbs. is out of the question, as the power lost by this method would mean throwing money away.

The fact that a cubic foot of air at 80-lbs. pressure is equal to about 3 cu. ft. at 15 lbs. leads most people astray, but if they consider that by taking the air for the sand blast from the shop system they have to compress the amount of free air per minute used by the blast at first to the shop pressure of 80 to 100 lbs., while, by having an extra compressor for the blast, it is only necessary to compress the certain amount of free air per minute used by the blast, to 15 or 30 lbs., they will realize the saving of power.

The principle on which the Farnham sand blasts work is to use a small nozzle and a high pressure and the amount of cubic feet of free air used by this blast, at this high pressure, is considerably less than the present machines use with the low pressure; in other words, the blast is worked just as economically by taking the air directly from the shop system as it is by having an extra compressor. In the latter case the great advantage is, that much smaller compressors can be used.

By using a small nozzle and high pressure, a smaller area (at a time) is covered than by the low pressure machines, but the area is covered much quicker and the total time consumed to cover a given area is the same for both machines, the high pressure machines having the advantage of doing much better work.

This blast has been used for the past three years in the United States and England with great success on exterior work, such as cleaning bridges, houses, etc., but recent tests at different railroad shops on castings, structural iron work, etc., have proven so successful, that it was decided to place the device on the market for use in foundry and machine shops.

The construction of the blast is very simple; in fact, almost everything is shown on the cut, the only thing not shown is an injector which is placed in the Y beneath the tank and directly in the center and underneath the sand discharge pipe.

The pipe leading into the top of the tank does not extend into the sand; it is simply there for the purpose of avoiding a vacuum or a back pressure from the injector when the tank is discharging the sand. On all present blasts this pipe extends through the sand into the mouth of the discharge and any moisture in the air is apt to clog up the sand at this point and prevent it from flowing freely. The sand which falls by gravity from the tank is also forced down by the air pressure on top and the suction created at the bottom by the injector.

The point, that all wearing parts are standard pipe fittings, should be appreciated by the customer. No special castings are employed and the only wearing part is the elbow at the bottom, which can be easily, quickly and cheaply replaced.

The hose, which is the only other wearing part, is ¾-in. diameter, and as other blasts employ considerably larger hose, the cost of maintenance of this machine will be lower.

The blast has a drain cock at the point where connection with the air system is made and the water, which will collect in the piping while the blast is idle, is to be blown off first before the blast is started.

Another point worth mentioning is, that the small opening in the injector will prevent an excessive air consumption when the nozzle wears out, the machine simply can not use more air than will pass through the small injector opening.

SULPHUR deposits of considerable value occur in the State of Louisiana. Great difficulty was at first experienced in dealing with these deposits, which occur at a depth of between 600 ft. and 800 ft. below the surface, by reason of the fact that the over-laying strata contained quicksand. The beds have been ascertained to be between 100 ft. and 200 ft. thick and extend for many miles underground. They are now being mined by means of steam and compressed air. Borings are driven into the stratum of sulphur, and a steam pipe leads down to the bottom of the bore. Steam is then forced down the pipe, and the melted sulphur is brought to the surface by a compressed air lift-pump system. At the surface it is discharged into large concrete-faced shallow vats or pools, where it is allowed to solidify, after which it is broken up and shipped to the refinery or direct to the market.

TESTS of a pneumatic hammer, states the *Industrial World*, reveal the fact that a very slight error of design or adjustment of the value may affect the efficiency of the tool to a very marked degree. With a certain hammer, giving 936 blows per minute, the piston had a velocity of impact of 38.56 feet per second at the end of the forward stroke. A slight improvement in the valve increased the number of blows to 1040 per minute, while the velocity of impact at the end of the forward stroke was 44.65 feet per second, resulting, of course, in a much more effective blow.

THE increasing use of compressed air in manufacturing and power plants, car barns, etc., has given quite an impetus to the manufacture of electrically driven air compressors which are self-contained and conveniently taken to the place where the compressed air is utilized. In drilling, riveting and chipping compressed air tools can be more advantageously employed than purely manual or mechanically operated devices. In electric railroad car barns or at steam railroad terminals compressed air is convenient and effectual in cleaning out dirt and dust. In power houses and substations it offers many advantages in blowing out dust from generator coils, field magnets and commutators. In automobile garages it is especially useful for inflating tires, cleaning dust from cushions, running gear, etc. The simplicity, flexibility, cleanliness and reliability of air as a source of power for a great many different purposes is coming to be better recognized.—*Iron Age.*

COMPRESSED air differs from electricity, especially in the fact that electrical friction losses cannot be regained, while corresponding losses with compressed air may be eliminated. The moderate fall in pressure in the air due to friction augments a loss of transmission. "If the air were at 80 lbs. gauge or 95 lbs. absolute upon enterting the pipe, and 70 lbs. gauge or 85 lbs. absolute at the other end, there would be a loss of a little more than 10 per cent. in absolute pressure, but at the same time there would be an increase of volume of 11 per cent. to compensate for this loss of pressure, and the loss of available power would be less than 3 per cent."

MANY experienced drill sharpeners gauge the bits by eye only. All drill sharpeners, no matter how expert, should be made to use a gauge in sharpening the steel. There is nothing more aggravating than wasting time in a hunt for a drill to follow one with a small bit. Many foremen are extremely careless in regard to the steel which they furnish to their miners.

A COTTON-PICKING machine has been invented by A. G. Kinyon, road foreman of the Southern Railway, that will straddle a row of cotton, and as the machine is drawn along it will draw portions of the cotton into a vacuum chamber. This chamber is connected with a suction apparatus of sufficient power to draw the staple from the boll, then through pipes into a box arrangement back of the machine.

The compressed air which operates the machine is generated by the wheels of the machine as it is drawn along the cotton rows.

U. S. PATENTS

ESPECIALLY PREPARED FOR COMPRESSED AIR

Full specifications regarding any of these patents may be obtained by sending five cents to the Commissioner of Patents, Washington, D. C. (Stamps will not be accepted.)

850,180. PNEUMATIC SPRING FOR VEHICLES. Vaclav H. Podstata and Frank M. Preucil, Chicago, Ill. Filed March 12, 1906. Serial No. 305,444.

850,208. AIR-COMPRESSOR. Einar J. Bring, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed May 7, 1904. Serial No. 206,913.

AIR OR OTHER GASES. Edward W. Lloyd and William H. Sodeau, Newcastle-upon-Tyne, England, assignors to W. G. Armstrong, Whitworth & Co., Limited, Newcastle-upon-Tyne, England. Filed June 22, 1906. Serial No. 322,935.

850,329. ELECTRIC AND PNEUMATIC GOVERNOR. Harry W. Young, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Jan. 22, 1906. Serial No. 297,147.

850,366. PNEUMATICALLY-OPERATED MUSICAL INSTRUMENT. John J. Healy, Monroe, N. Y., assignor of one-half to Solomon F. Hess, Rochester, N. Y. Filed Dec. 9, 1904. Serial No. 236,251.

850,564. AIR-BRAKE MECHANISM. John J. Coit, Venice, Cal. Filed Nov. 15, 1906. Serial No. 343,560.

850,387. PNEUMATIC SPRING. Alonzo C. Mather, Chicago, Ill. Filed Aug. 22, 1906. Serial No. 331,572.

850,592. PNEUMATIC VIBRATOR OR HAMMER. Wilfred Lewis, Philadelphia, Pa., assignor to The Tabor Manufacturing Company, Camden, N. J., a Corporation of New Jersey. Filed Oct. 5, 1906. Serial No. 337,502.

850,327. PNEUMATIC TREAD FOR BOOTS AND SHOES. Isidor Tauber, Vienna, Austria-Hungary. Filed Nov. 16, 1906. Serial No. 343,707.

850,639. PNEUMATIC DEVICE FOR DRAWING OUT GRAINS AND SIMILAR GOODS. Paul Gebhardt and Carl Gebhardt, Stralau, near Berlin, Germany. Filed Sept. 24, 1906. Serial No. 336,029.

850,635. PNEUMATIC VALVE FOR MUSICAL INSTRUMENTS. August W. Flegel, Cranford, N. J., assignor to The Aeolian Company, New York, N. Y., a Corporation of Connecticut. Filed Oct. 18, 1906. Serial No. 339,439.

850,674. COMPRESSED-AIR SPRAYER. Clarence W. Parks and Agnes E. Parks, Lowell, Mich. Filed Sept. 9, 1905. Serial No. 277,759.

850,700. PNEUMATIC COTTON-HARVESTER. James E. Worswick, Montgomery, Ala., assignor of one-half to George P. Haardt, Montgomery, Ala. Filed May 19, 1906. Serial No. 317,781.

850,706. MEANS FOR INFLATING PNEUMATIC TIRES. Albert A. Withers, Balaclava, Victoria, Australia. Filed Aug. 28, 1905. Serial No. 276,178.

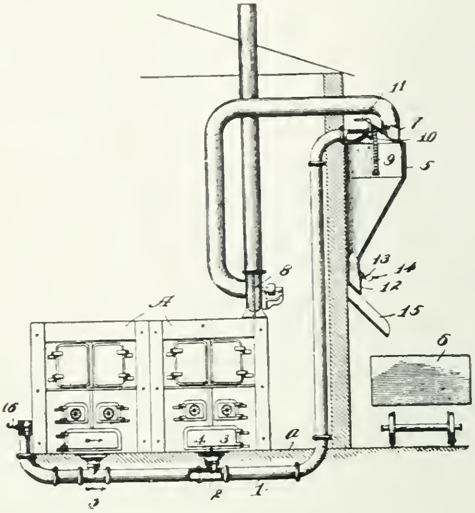
849,599. AUTOMATIC EMERGENCY-BRAKE. William Cooper, Georgetown, Colo. Filed Dec. 18, 1906. Serial No. 348,406.

850,909. NOZZLE FOR PNEUMATIC CARPET-CLEANING APPARATUS. Ralph F. Diserens, Bradford, Pa. Filed July 5, 1906. Serial No. 324,733.

850,956. PNEUMATIC TIRE. George L. McQuigg, Flint, Mich. Filed Oct 11, 1906. Serial No. 338,436.

850,999. DISK DRILL. Spencer E. Davis, Minneapolis, and Thomas Brennan, Jr., St. Louis Park, Minn. Filed July 23, 1906. Serial No. 327,261.

851,054. PNEUMATIC CONVEYER. Edwin M. Bassler, Chicago, Ill., assignor to The Economic Engineering & Construction Company, Chicago, Ill., a Corporation of Illinois. Filed Aug. 4, 1905. Renewed Sept. 28, 1906. Serial No. 336,597.



Claim.—In a conveyor, the combination of a conduit provided with an admission opening or openings, a receptacle into which said conduit discharges, said receptacle being provided with an air-discharge opening, means to create a current of air through said conduit and means to wet the material delivered into said receptacle from said conduit.

851,334. DIAPHRAGM-PUMP. George J. Altham, Swansea, Mass., assignor to Aero and Marine Motor Company, Boston, Mass., a Corporation of Massachusetts. Filed July 17, 1905. Serial No. 269,914.

851,338. SAFETY-CLUTCH FOR AIR-BRAKE ANGLE-COCKS. Sidney J. Barnhouse, Alexandria, Va., assignor of one-third to John G. Bayne, Alexandria, Va. Filed Feb. 8, 1905. Serial No. 244,817.

851,362. SIGNAL APPARATUS. Ernest de Merindol Malan, London, England. Filed Dec. 5, 1906. Serial No. 346,433.

851,364. CENTRIFUGAL PUMP. Elof Meden, Trenton, N. J., assignor to The Jeanesville Iron Works Company, Hazleton, Pa., a Corporation of Pennsylvania. Filed April 5, 1905. Serial No. 253,979.

851,393. PNEUMATIC WHEEL-SUPPORT. George W. Bell, Liverpool, England. Filed Jan. 31, 1906. Serial No. 298,759.

851,472. PNEUMATIC MOTOR. Philip Wuest, Jr., Philadelphia, Pa., assignor to The Auto-Manual Piano Action Company, Philadelphia, Pa., a Corporation of New Jersey. Filed Sept. 19, 1906. Serial No. 335,167.

851,556. DRIVING MECHANISM FOR AIR-COMPRESSORS. Bryan Obear, St. Louis, Mo., assignor to Montague Compressed Air Company, St. Louis, Mo., a Corporation of Missouri. Filed Feb. 1, 1905. Serial No. 243,711.

851,624. PNEUMATIC TOOL. Charles H. Haeseler, New York, N. Y., assignor to Ingersoll-Rand Company, a Corporation of New Jersey. Filed Feb. 21, 1907. Serial No. 358,605.

851,754. CARRIER-SEPARATOR FOR PNEUMATIC-TUBE APPARATUS. Chester S. Jennings, Brookline, Mass., assignor to Lamson Consolidated Store Service Company, Newark, N. J., a Corporation of New Jersey. Filed June 21, 1906. Serial No. 322,791.

851,766. AUTOMATIC BRAKE. Johann J. Muller, Zurich, Switzerland, assignor to Henry Baer and Company, Zurich, Switzerland. Filed Sept. 22, 1906. Serial No. 335,792.

851,237. PNEUMATIC STACKER. Ole Holden, Britton, S. D. Filed May 31, 1905. Serial No. 263,173.

851,316. AUTOMATIC AIR-SIGNAL, AIR-BRAKE, AND STEAM COUPLING. Herman C. Priebe, Blue Island, Ill. Filed July 31, 1906. Serial No. 328,552.

851,818. AIR-BRAKE SYSTEM AND ENGINEER'S VALVE. George Macloskie, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Nov. 9, 1905. Serial No. 286,513.

851,874. AUTOMATIC CAR-BRAKE. Charles Fero, Jr., Bay City, Mich., assignor of one-third to Frank Thompson, Bay City, Mich. Filed Oct. 8, 1906. Serial No. 338,041.

852,007. AIR-BRAKE APPARATUS. Robert J. Wilson, Pittsburg, Pa. Filed Nov. 16, 1905. Serial No. 287,664.

852,046. DRILLING-MACHINE. Erik Westberg, Geoff, N. D. Filed July 7, 1906. Serial No. 325,125.

852,108. AIR-BRAKE SYSTEM. Daniel M. Daley, West Seneca, N. Y. Filed May 29, 1906. Serial No. 319,369.

852,109. DRILL. Dean B. Edwards, Wauchope, Saskatchewan, Canada. Filed Aug. 3, 1906. Serial No. 329,063.

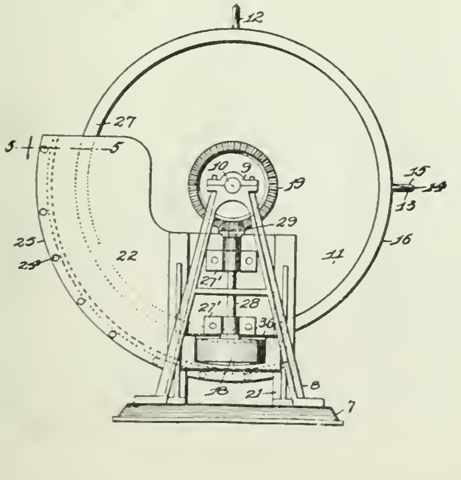
852,117. PNEUMATIC APPLIANCE FOR CARS. George H. Hollingsworth, Belmont, Mass., assignor to Consolidated Car Fender Company, Providence, R. I., a Corporation of Rhode Island. Filed Feb. 12, 1907. Serial No. 357,084.

852,157. SAFETY-VALVE FOR AIR-BRAKES. Thomas Behan, Alliquippa, Pa. Filed March 20, 1906. Serial No. 307,115.

852,161. PNEUMATIC PLAYER FOR MUSICAL INSTRUMENTS. George P. Brand, New York, N. Y. Filed Feb. 23, 1905. Serial No. 246,864.

852,541. AIR-COMPRESSOR. Reginald A. Cousans and Louis B. Cousans, Lincoln, England. Filed Nov. 30, 1903. Serial No. 183,305.

852,749. ROTARY AIR-COMPRESSOR. Gustav C. Vollmer, St. Louis, Mo. Filed Jan. 15, 1906. Serial No. 296,068.



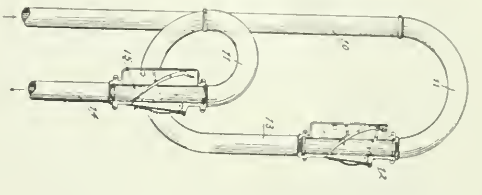
Claim.—A rotary air compressor comprising a revolving member mounted upon a shaft, a casing forming a compression chamber through which the revolving-member operates, said casing covering a portion of the revolving-member, a cut-off located at the bottom of the revolving-member and operated by the revolving-member, said cut-off having its upper casing concave and its lower face convex to correspond with the formation of the casing and the periphery of the revolving-member, and provided with a recess for the admission of the revolving-member, substantially as specified.

852,817. AIR-COMPRESSOR. Reinold Berrenberg and Alonzo S. Drisko, Boston, Mass. Filed March 16, 1905. Serial No. 250,458.

852,889. PISTON FOR AIR-COMPRESSORS. Robert Miehle, Chicago, Ill. Filed July 24, 1905. Serial No. 270,917.

852,899. AIR-BRUSH. Jens A. Paasche, Chicago, Ill. Filed Sept. 8, 1906. Serial No. 333,743.

852,913. PNEUMATIC-DESPATCH APPARATUS. Fred R. Taisey, Indianapolis, Ind., assignor to The Lamson Consolidated Store Service Company, Boston, Mass., a Corporation of New Jersey. Filed May 24, 1906. Serial No. 318,474.

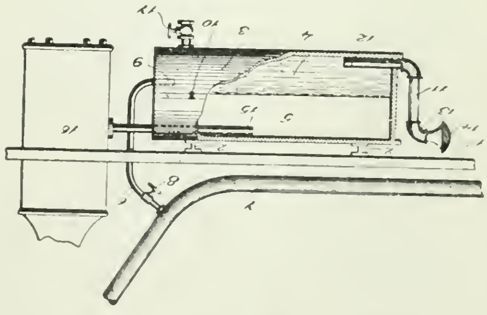


Claim.—A terminal in a pneumatic despatch apparatus having a passage-way therethrough and a discharge opening, a director projecting into the passage-way therein in a position when locked to deflect a carrier through the discharge opening, and means pivoted on the deflecting end of said director which projects into the passage-way and operable by a carrier for locking the director.

852,924. PRESSURE-REGULATING VALVE. Richard E. Bruns, Chicago, Ill. Filed July 10, 1905. Serial No. 268,935.

852,976. AUTOMATIC REGULATOR FOR AIR AND GAS COMPRESSORS. Fred E. Norton, Youngstown, Ohio. Filed April 11, 1906. Serial No. 311,033.

853,137. AIR-CLEANER FOR AIR-BRAKE SYSTEMS. Roston S. Wallace, Birmingham, Ala. Filed Nov. 3, 1906. Serial No. 341,933.



Claim.—An air cleaner for air brake systems comprising a cylindrical reservoir containing a body of water, an air chamber above the water line, an intake air pipe terminating at a point below the water line and extending above the water line outside the reservoir, and provided with a screen at its intake end, an outlet air pipe extending into the air chamber and connected to the pump for supplying air to the brake system.

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Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

JULY, 1907.

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THE ANTECOOLER, THE INTERCOOLER AND THE AFTERCOOLER

By Frank Richards.

These devices are unique among industrial apparatus in that they accomplish desirable results, also of actual, computable commercial value, and yet cost nothing for their working. They consume no raw material and require not even lubrication. The water which flows through them, even when water is scarce, is still as usable as before for boiler feeding or any other purpose.

The cost of these coolers in connection with air compression may be said to consist entirely of the fixed charges, the original cost of the apparatus employed and then the customary allowance for depreciation and maintenance. As to the maintenance, there is no wear or liability of breakage; but there is some oxidation and some deposition of sediment and some clearing out occasionally required, the overhauling thus entailed comparing with the repairs and renewals required for the working and wearing parts of the compressor.

The chief function of the cooler attached to an air compressor is the reduction of the volume of air to be compressed, the reduction of volume entailing a direct proportional saving in the power required. A reduction of 5° Fahr. means a reduction of 1 per cent. in the power required to compress any given quantity or weight of air. There are also important incidental advantages, which will appear later. The air may be cooled before compression by means of an "antecooler"; between two stages of compression, by an "intercooler"; or after compression, in which case the apparatus is called an "aftercooler."

The antecooler is regarded by many as a mere refinement in air compression; yet it works quite as cheaply as the intercooler and there are many cases in which it could be employed with profit, especially in summer, and in all cases where very cold water is available.

THE INTERCOOLER.

The intercooler implies the compound or two-stage compressor, the two stages having the double purpose of avoiding high and dangerous temperatures and of saving power in the second compression on account of the considerable reduction of volume. The intercooler also, until very high pressures are reached, is apt to be regarded as an unprofitable refinement. The question of its utility is, however, not to be determined by opinion or prejudice. It should be approached in the same spirit as the question whether a given compressor should be a single-stage, a two-stage, a 20-inch, or a 24-inch machine, the ultimate question in either case being as to which is the best machine for the purpose intended.

The precise pressures which should be reached in two stages is an open question;

also the upper limit of single-stage compression. In the plants employed in the tunnel work, now going on about New York, we generally find two different systems, and two entirely separate and different sets of compressing apparatus, one for high and the other for low pressure, the former going up to 125 pounds gauge, and the latter being expected to go no higher than 50 pounds. In the service here referred to, the low-pressure compressors work most of the time at 20 to 30 pounds, but there are many compressors in different locations where 50 pounds is the pressure to be constantly maintained, and then the value of two-stage compression may be worth looking into.

COMPARATIVE COST.

Suppose that we have to deliver compressed air constantly at 50 pounds, gauge, taking in air at 60°, and compressing in a single cylinder. Take a 30-inch diameter cylinder at 400 feet piston speed. The free air capacity will be 1,963 cubic feet per minute, the mean resistance for the compression stroke (adiabatic compression) will be 27.39 pounds per square inch, and the horse-power required will be 234.67.

Let us compare this with a system of two-stage compression, with an intercooler between the stages. The diameter of the first cylinder and the piston speed are the same as before, giving an equal free air capacity. We compress in the first cylinder to 25 pounds, this pressure being fixed by the relative capacities of the first and the second cylinders and remaining constant regardless of the final or delivery pressure. The mean resistance, then, in the first cylinder (adiabatic compression) will be 17.01 pounds, and the horse-power will be 145.74.

If the air thus compressed is then cooled to the original temperature, the pressure being maintained, the reduced volume will be inversely as the increased absolute pressure, 40 : 15, or 8 : 3, and for the second cylinder the piston area ratio should be the same, which would make it 18⅜ inches diameter. The mean effective resistance for the second compression, from 25 to 50 pounds, would be 20.84 pounds, and the horse-power would be 66.99, say 67, making the total horse-power $145.74 + 67 = 212.74$, which is apparently a saving of 9 per cent. over the single-stage compression. As the intercooler would probably not cool the air quite to the original temperature, and as the friction of the mechanism as a whole would be slightly increased, the saving would probably be not more than 5 per cent. at the best, so that in compressing to 50 pounds it is doubtful whether two-stage compression with intercooling would be profitable.

WHEN THE TWO-STAGE SYSTEM IS PREFERABLE.

The great majority of compressors in use work at higher pressures than this, say from 75 to 90 pounds, gauge, this being the working pressure for rock drills, and for most of the air-operated tools of the shops. With the same cylinder data as before, 30 inches diameter and 400 feet piston speed, the mean effective resistance in compressing adiabatically to 75 pounds single stage will be 35.23, and the horse-power 301.85. With two-stage compression, compressing in the first cylinder to 30 pounds, the mean effective resistance for this compression will be 19.4 pounds, and the horse-power 166.3. For the second cylinder the diameter would be 17.32 inches, the mean effective resistance 34.56, and the horse-power 98.7, making the total horse-power 265, or a little more than 12 per cent. less than for single-stage compression. Taken inversely, the power cost of single-stage over two-stage compression to 75 pounds, with perfect cooling, is nearly 14 per cent.

To compress to 90 pounds, single stage, the mean effective resistance would be 39.18 pounds, and the horse-power 335.71. Using the same two-stage cylinders as in the preceding case and compressing to 90 pounds, the work of the low-pressure cylinder would be the same as before, and the horse-power the same, 166.3. For the high-pressure cylinder, compressing from 30 to 90 pounds, the mean effective resistance would be 43.41 pounds, and the horse-power 123.97, making the total horse-power 290.27, or nearly 14 per cent. below that for single compression, while in terms of the two-stage compression the excess of horse-power for the single stage would be more than 15½ per cent. The gain here would seem to be beyond question.

DRY AIR AND LUBRICATION.

The intercooler does more than to reduce the horse-power required for a given compression and to secure safe and comfortable working temperatures. It does much to remove what is in some cases the most serious objection to the employment of compressed air. Dry air can not freeze up, and the intercooler helps to dry the air. This drying of the air is the special function of the aftercooler. The dryness of air is always comparative. The air is at its highest pressure, when it leaves the compressor. If it can then also be reduced to the lowest possible temperature its moisture-carrying capacity will be at a minimum. The air will then be so wet that it will deposit moisture. The water should at this stage be given every chance to drop out, so that, when the pressure falls and the temperature rises, the same air will remain dry air while in use.

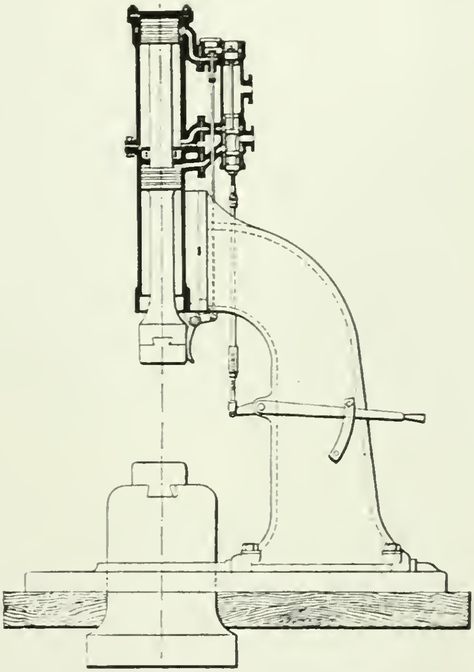
If the air is not cooled, and thus dried before it starts on its course through the pipes, it will begin dropping water as it goes along. In freezing weather in outdoor work, as in quarries, and especially in switch and signal work, the moisture will freeze and gradually choke the pipe, or some of the ice will be carried along to an elbow or to some depression and form a solid obstruction. When the moisture is not in excess in the air there can be no freezing up. In weather which is not freezing the moisture which is precipitated is the cause of "water hammer" and leaky joints. Air which has not been dried by cooling also interferes with lubrication. Oil and water will not mix, and when moisture condenses upon surfaces requiring lubrication the oil can not get at those surfaces.

Any device which thus works so cheaply and accomplishes so much of value, which treats its employer so generously, certainly deserves some appreciation and liberality of treatment in return. We may assume, of course, that the intercooler is sure of employment in two-stage compression and that two-stage compression will be more frequently employed as the economy of it becomes better known, but the antecooler and the aftercooler are also deserving of consideration and should often be employed in situations where they are now unknown. Wherever either is employed the service it renders is so cheap that liberal dimensions, ample cooling surfaces should not be begrudged it.

A NEW COMPRESSED AIR HAMMER

The cut, which we reproduce from *The Engineer*, London, shows a hammer to be operated by compressed air, built by C. & A. Musker, Limited, Liverpool, Eng. This hammer is built in sizes from 3 cwt. to 5 tons, and gives blows of the same energy and quality as when operated by steam. It is announced that the hammer is designed for pressures from 40 to 120 pounds, and this is accompanied by the rather questionable statement that 40 pounds is to be preferred "as it is a well attested fact that the low pressure is more economical to produce, and is a more economical power-transmitting agent, added to which the trouble with pipe joints and leakage is minimized."

The hammer is worked by the hand bar, the same as a steam hammer. Assuming the tup or ram to be at the top and the valve down, as shown, to strike a light blow the valve is moved upward only far enough to admit the air above the lower piston, the same movement of the valve allowing the air under the upper piston to be discharged through the middle part to the lower exhaust.



NEW COMPRESSED AIR HAMMER.

To raise the tup the valve is lowered sufficiently to allow the air supply to enter the middle port, exhausting the air from above the piston in the lower cylinder through the lower port to the lower exhaust. The miter valve is opened by the exhausting of the air.

To give a heavy blow, the valve is moved upwards, allowing the air to go through the upper port under the miter valve, and to act upon the upper side of the upper piston and at the same time through the center of the valve to the lower port, and to act upon the top of the lower piston, the air thus acting on both pistons at the same time.

For the upward stroke, the valve is reversed; air pressure is admitted underneath the upper piston through the middle port, and the air above the two pistons is exhausted through the higher and lower ports respectively.

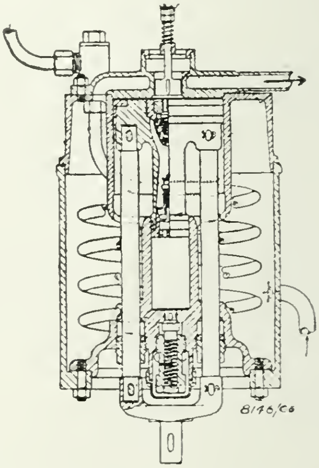
The miter valve is for the purpose of using the air expansively, without wire-drawing, when striking heavy blows. It is arranged to be kept open by a curved bar resting against the tup until the latter descends about half stroke, when the lever is freed and the valve descends, cutting off the supply, the remainder of the stroke being driven by the expansion of the air.

Economy in working results from both the using of the lower piston only for light blows and from the expansive use of the air when the upper piston with the larger area is used. A comparative test of air hammers was made by Sir William Armstrong, Whitworth & Co., Limited, with the result, as stated, that the Musker hammers used less than half the air required for the others.

USELESS TWO-STAGE COMPRESSION

It is, we suppose, generally understood, at least by our readers, that there is no reason for two-stage compression of air except for the opportunity it provides for the cooling of the air between the stages and the reducing of its volume before the second compression. In this way the high temperatures, always objectionable as to lubrication, and sometimes dangerous as causing ignition and explosion, are avoided, and the reduction of volume results in a distinct saving of power.

A recent British patent for an "Improved" Two-Stage Air Compressor—the inventor an Italian—is of interest chiefly as showing how completely the essential conditions of economical—as well as safe—air compression can be ignored. In this compressor, shown in the sketch, there are two vertical open-ended air cylinders, the larger one above. A single piston is provided with a large end fitting the upper cylinder and a small end fitting the smaller cylinder below, the piston of each cylinder being single acting. The piston is actuated by two rods attached at each end of the enlarged head of the piston and united by a yoke below. Starting from the position shown, the piston descends and the upper cylinder is filled with air, which enters by a central valve at the top. When the piston rises this air passes down through the middle of the piston into the smaller cylinder, the transfer into the smaller cylinder practically compressing the air. A valve in the piston closes and when the piston descends this charge of air is expelled, passing through a valve in the bottom of the cylinder. In the meantime the upper cylinder has been filled again, and so the operation goes on. There has been not the slightest provision for cooling the air all through the compression. The compressed air now passes through the pipe coil in the water chamber surrounding the cylinders and is then probably well cooled, but too late to have the good effect which should have been expected.

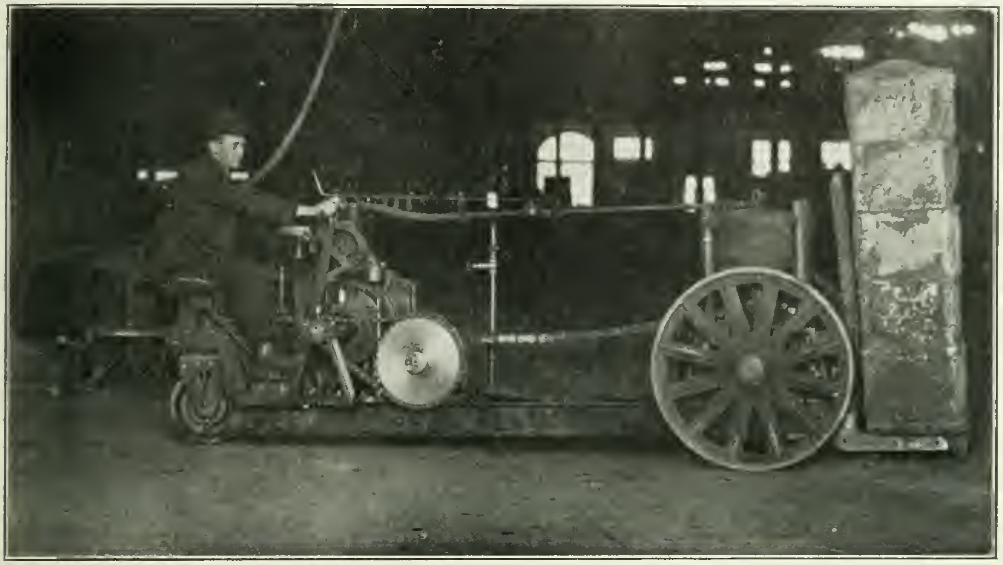


USELESS TWO STAGE COMPRESSION.

It is claimed for this arrangement that certain valves, packings, stuffing boxes, etc., are gotten rid of. If the compression had all been done in the upper cylinder with an inlet and an outlet valve in the top, how much simpler it would have been. In this case, besides the multiplication of parts, the two stuffing boxes, through which the vertical rods pass, should not be overlooked.

AIR OPERATED TRUCK FOR MALLEABLE IRON FURNACES

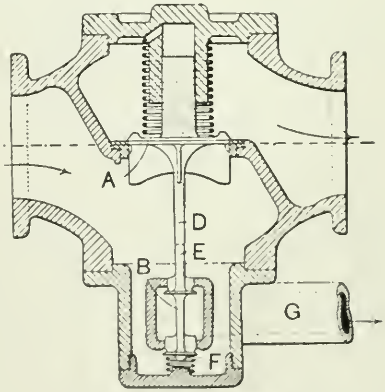
The half-tone shows a charging truck in successful use in malleable iron foundries. The truck is connected to the air supply by a long suspended hose, which gives it room to travel back and forth in front of the furnaces and to run in or out of them, as required. The truck is three-wheeled, the third wheel under the drivers' seat, and the locomotive is accomplished by a Dake engine chain-connected to the wheels. The lifting of the annealing boxes is done by a vertical slide with projecting toes which go under the box, or a pile of boxes, lifting only high enough to clear the ground, and when the truck has carried the load to the point required letting it down again. There is an air cylinder of sufficient diameter, the piston of which operates the vertical slide for the lift. The capacity of the machine is 100 tons per day, and to operate it requires about 200 cubic feet of free air per minute at various pressures, according to the load. This truck may be another means of introducing the air compressor, and when it is in use then may come calls for pneumatic tools, then for a larger compressor, and so on.



AIR OPERATED TRUCK FOR MALLEABLE IRON FURNACES.

RATEAU'S NON-RETURN VALVE

If one is dealing with a centrifugal fan drawing from the atmosphere and discharging into a reservoir in which the air is already under pressure, it is necessary to arrange between the delivery outlet of the fan and the reservoir a non-return valve which will automatically close and prevent the air in the reservoir escaping when the pressure of the fan is insufficient. During the working of the fan, so long as the speed of rotation fails to reach a sufficient value, the fan produces a



RATEAU'S NON-RETURN VALVE.

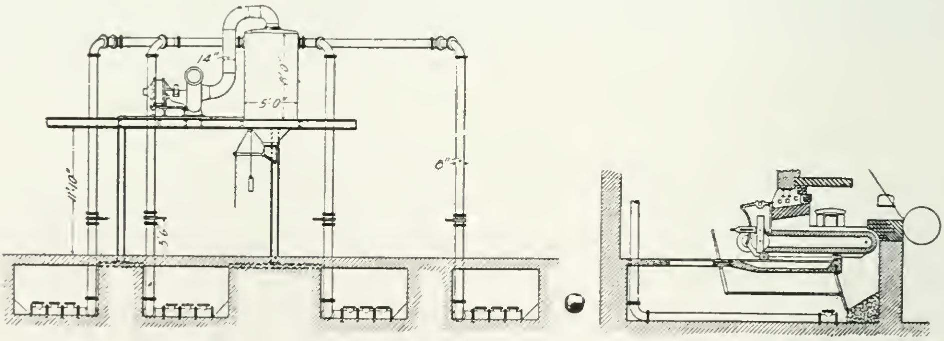
pressure too small to open the valve, and the output is nil. Under these conditions the elastic fluid acquires within the apparatus a pulsatory movement, flowing and returning alternately at periods of time which vary according to circumstances. This pulsatory action persists, and causes a loss of energy and considerable heating of the fluid to take place.

To obviate this objection the device shown in the accompanying illustration has been patented by Mons. A. Rateau, of 20, Rue d'Anjou, Paris. When the output of the fan falls to a value such that the pulsatory action can come into existence an escape orifice is opened. In the illustration A is a non-return valve arranged on the conduit leading from the fan to the reservoir. B is the valve (in the example a double-beat balanced valve) which closes the escape pipe G during normal working but which opens when the non-return valve A closes. This is brought about simply by the contact of the extremity of the stem D of the valve A with the extremity E of the stem of the valve B. As soon as the valve A is raised by the pressure of the gaseous current becoming sufficient, it allows the valve B to be acted on by the spring F, which closes it against its seat.

PNEUMATIC ASH-CONVEYOR SYSTEM.

In boiler plants the problem of handling ashes is solved in many ways more or less economical. A recent issue of the *Electrical Review* describes a system which is entirely new and original. At the Evanston (Ill.) plant of the North Shore Electric Company there is a pneumatic ash-conveyor system that has shown itself capable of disposing of ashes in a satisfactory and very economical way. The essential parts of this system for pneumatically handling ashes are a No. 7 Sturtevant exhaust fan direct-driven by a 40 H. P. motor. A 14-inch pipe connects the fan with the top of a "separator." Leading into this separator are 8-inch wrought iron pipes, which extend to the ash pits under the grates, where openings are provided for allowing the ashes to pass into the pipes. On account of the expense which would have been necessary to place one ash-collector header through the row of ash pits, as in other installations, it was in this instance thought best to use more piping in the form of risers as shown in the drawing. The separator is mounted between two of the boilers, and at the rear, at such an elevation that a wagon may be driven under it and loaded with ashes from a track. The small headroom limited the capacity of this separator to 8,000 cubic feet, but for installations in power plants of more modern design it is proposed to place a concrete ash bunker just below the separator so that a large storage capacity may be had.

When it is desired to empty the ash pits the exhaust fan is started, thus creating a vacuum of about one pound per square inch in the separator and the pipes connected with it. This vacuum rapidly draws the ashes that have accumulated around the openings in the ash pits into the pipes and through them to the separator, where, by means of a spray head and baffles they are wet down and discharged to the bottom of the separator hopper. Blast gates are provided in the lead from each ash pit so that if desired each pit may be cleaned individually. Due to the great difference in velocities of the air, which in the pipes connecting with the ash pit and serving to carry



PNEUMATIC ASH-CONVEYOR SYSTEM.

away the ashes is 18,000 feet per minute and in the separator but 500 feet per minute, there is no trouble from ashes passing the separator, and damaging the exhaust fan. It is also observed that the ashes travel through the center of the space in the pipes, rather than along the sides. This is due to the greater velocity of the air in the center where the friction is less and thus the pipe work is free from the wear that would ordinarily be expected.

Before this system of handling ashes was installed at the North Shore plant it required four men ten hours a day to keep the ash pits clean. It was first necessary to go into the hole, shown in the drawing, in front of the boilers and shovel the ashes from their piling place back 12 feet to a point under the hole; then they had to be handled again and thrown on to the boiler-room floor where a third handling was necessary to load them for carrying out of doors. With the new ash-handling equipment one man does the work of the four in one-fifth of the time or two hours; thus, the economy of the installation, which only requires about 25 H. P. motor capacity during such times as ashes are being removed, is made apparent. As ordinarily operated the ashes are removed at the rate of 300 pounds per minute and by varying the speed of the motor both ashes and clinkers may be handled in quantities up to 500 pounds per minute.

A YELLING LIGHTHOUSE

On the French coast there will soon be a lighthouse equipped with monster mouths and a compressed air device, which will enable it to shout, in tones of thunder, to ships on the horizon. The invention by Dr. Marage, an ear specialist of Paris, is not a phonograph or anything like it, but an exact imitation of the human throat and mouth, with an air pump for lungs.

Teeth, lips, jawbones and all are imitated exactly. Dr. Marage's small models, hardly appreciably larger than the normal human mouth, can be made to utter a faint whisper or give vent to an ear-splitting yell such as no man ever made.

With a mouth six feet from corner to corner, it is estimated that the artificial voice could be understood from three to six miles away, according to weather conditions. Mouths of this size are to be placed beneath the lens of the new French lighthouse.—*Exchange Unidentified.*

DRILLING BOLT HOLES IN GREEN CONCRETE

The drilling of bolt holes in partially green concrete is a tedious process, owing to the wedging of the drill. One contractor seems to have hit upon a simple method of drilling these holes and at the same time avoiding the delay caused by the wedging of the drill. He used a compressed air drill hung on the guides of a small pile driver frame, the drill occupying the same position the hammer would occupy in pile driving. The drill was suspended by a wire rope and raised or lowered by means of a hand windlass. One of the advantages of this arrangement was that a longer drill could be used than by the ordinary tripod arrangement. A small metal pipe was carried into the hole with the drill, and through it water was forced under heavy pressure, carrying off the chips and thus preventing wedging. Many of the holes were bored in partially green concrete to a depth of 6 feet or over.—*Engineering Contracting.*

Some idea of the immense driving force that can be attained by compressed air will be realized when it is stated that under a pressure of about 2,000 pounds, a shaft of air penetrating through an orifice—no larger than a tiny pin point—would instantly bore a hole through a 2-inch plank of solid oak.

The above compressed air wonder has been started on its circuit of the pseudo-technical press, and we are likely to see it doing frequent duty as a column filler. Who first "stated" it is not known, nor is it known who has done the trick.

THE FLOW OF AIR IN LONG TUBES, WITH SPECIAL REFERENCE TO PNEUMATIC DISPATCH

By B. C. Batcheller.

PART IV.

Culley and Sabine's Experiments.‡

In a paper read before the Institution of Civil Engineers, London, Messrs. Culley and Sabine give the results of some experiments made with the small pneumatic tubes of the London post office, connecting central and branch offices. From the data obtained in these experiments it is possible to compute the co-efficient of friction. The tubes were of lead, 0.1823 ft. inside diameter, slightly moist from condensation. The time of transit was obtained by dispatching a light felt carrier through the tube. The pressures were measured by mercury manometers. From the data given in table D, p. 79, of Messrs. Culley and Sabine's paper, the co-efficient of friction has been computed by the use of formula (35), and results tabulated below. The temperature of the air in the tube is not given for each experiment and was evidently not measured. The paper states: "Some observations were made on the temperatures of different tubes, the results of which were very various. Generally, however, the temperature of the air in issuing is lower than on entering a tube, but not to the exent corresponding with the expansion. As an instance, the following observations at different points of the Cannon street tube showed that the actual fall of temperature through the expansion is, from these causes, rendered comparatively little."

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‡See Proceedings Institute Civil Engineers, London, Nov. 16, 1875; "Pneumatic Transmission of Telegrams."

	Central Sta. Deg. Cent.	Cannon St. Deg. Cent.	Thames St. Deg. Cent.
Temperature of air in pressure pipe........................	26°.6	10°.0	13°.8
Temperature of office from which air was drawn........................	17°.7	15°.5	15°.5
Temperature of air in vacuum pipe..	13°.3	12°.7	13°.3

In computing the coefficient of friction the temperature has been assumed in all cases to be 60° Fahrenheit.

CULLEY AND SABINE'S EXPERIMENTS.

d=0.1823. PRESSURE.

No. of Experiment.	Distance Feet. L	Initial Absolute Pressure Pounds Per Sq. Inch. P_1	Final Absolute Pressure Pounds Per Sq. Inch. P_2	Time of Transit Seconds t	Coefficient Of Friction f Computed by (35)	Mean Carrier Velocity um	Tube Between Central Station and
1	5523	22.7	14.7	175	0.006133	31.56	Thames St.
2	4923	21.2	14.7	173	0.007224	28.46	Mark Lane
3	4227	22.83	14.7	121	0.006617	34.93	Fenchurch St.
4	4014	23 2	14.7	106	0.006126	37.78	Eastcheap
5	3576	20.2	14.7	104	0.005960	34.38	Baltic Coffee House

Mean.............. 0.006412

VACUUM.

No. of Experiment.	Distance Feet. L	Initial Absolute Pressure Pounds Per Sq. Inch. P_1	Final Absolute Pressure Pounds Per Sq. Inch. P_2	Time of Transit Seconds t	Coefficient Of Friction f Computed by (35)	Mean Carrier Velocity um	Tube Between Central Station and
6	5523	14.7	22.7	145	0.006924	38.10	Thames St.
7	4923	14.7	21 2	140	0.007188	35.16	Mark Lane
8	4227	14.7	20.95	108	0.006460	39.14	Fenchurch St.
9	4014	14.7	19.95	118	9.007374	34.02	Eastcheap.
10	3867	14.7	19.95	108	0.006908	35.81	Gresham House.
11	2895	14.7	20.2	67	0.006683	43.21	Cornhill,
12	2862	14.7	20.2	70	0.007550	40.90	Lloyds.
13	2751	14.7	19.95	68	0.007607	40.46	Telegraph St.
14	2424	14.7	20.2	54	0.007395	44.90	Founders Court.
15	2331	14.7	19.2	54	0.006618	43.17	Ludgate Circus.

Mean..............0.007071

Mean of all experiments—**f** = 0.006851.

For a tube 0.1823 ft. diameter, Prof. Unwin's formula gives

$$\mathbf{f}\ 0.0027\left(1+\frac{3}{10\times 01.823}\right)=0.007143$$

Arson's Experiments.

Prof. Unwin has compiled the results of several experiments on the flow of air in long pipes (to be found in the minutes of the proceedings of the Institute of Civil Engineers, London), from which I will make some quotations:

"In the Cours d'Hydraulique of M. Phillips, page 300, there are given the results of some experiments on the flow of air, by M. Arson. The co-efficient of friction was found to vary sensibly with the velocity and M. Arson adopted the well-known expression

$$f = \frac{a}{v} + b$$

for the co-efficient of friction, in which a and b are constants and v is the velocity of air in feet per second. Reducing M. Arson's results to foot and pound units, the following values of a and b are obtained for cast-iron pipes:

Dia. of pipe, Feet.	a	b	f For 100 feet per second.
1.64	0.00129	0.00483	0.00484
1.07	0.00972	0.00640	0 00650
.83	0.01525	0.00704	0.00719
.338	0.03604	0.00941	0 00977
.266	0.03790	0.00959	0.00997
.164	0.04518	0.01167	0.01212

It will be seen that at velocities exceeding 20 or 30 feet per second the first term $\frac{a}{v}$ in the expression for **f** varies very greatly with the diameter of the pipe, as is known to be the case with water."

Interpolating in the above table, for a tube 6⅛ in. diameter (0.5104 ft.) a = 0.0248 and b = 0.0086; for a tube 8⅛ in. diameter (0.6778 ft.) a = 0.019 and b = 0.0079. Using these values in the expression

$$f = \frac{a}{v} + b$$

we have computed the following table for the purpose of comparison with the experiments made in Philadelphia:

Velocity feet per second.	**f** for d = 0.5104 $\frac{a}{v} + b$.	**f** or d = 0.6778 $\frac{a}{v} + b$
20	0.00984	0.00885
30	0.00943	0.00853
40	0.00922	0.00837
50	0.00910	0.00828
60	0.00901	0.00822
70	6.00895	0.00817

These values of **f** are much greater than those obtained from my experiments, but the difference may be partly due to the rough surface of the cast-iron pipes with which M. Arson's experiments were made. There is less variation with the velocity than my results show.

Stockalper's Experiments.

In 1879 M. Stockalper published a pamphlet at Geneva, in which he gives the results of experiments made at Saint Gothard's tunnel on the flow of compressed air in long metallic conduits for the transmission of power. The experiments were made with two pipes, one 20-c.m. (0.656-ft.) diameter, 4600 metres (15,092 ft.) long, partly of cast, partly of wrought iron, having joints made with flanges, bolts and rubber gaskets; the other 15-c.m. (0.492-ft.) diameter, 522 metres (1713 ft.) long, of wrought iron, having joints made in the same manner.

The velocity of the air in the piper was computed from the revolutions of the compressor, the volumetric efficiency having been determined by a previous experiment in filling a reservoir of 166.50 cubic metres capacity. The pressure in the pipes was measured with Bourdon gauges, on which 1/20 of an atmosphere could be read and a curve of corrections was made for each gauge by comparison with a manometer. The temperature of the air was measured by means of thermometers inserted into the pipe and corrections applied for the exterior pressure on the thermometers.

M. Stockalper attempts to show that Darcy's formula for the flow of water can be applied to the flow of air if the results be multiplied by the ratio of the densities of water and air, but it is obvious that such a formula, neglecting as it does, the work of expansion, can not give correct results.

In the table on the next page Stockalper's results have been reduced to English units and the value of the co-efficient **f** for each experiment computed.

By the Unwin formula, for a pipe 0.656 ft. diameter—

$$f = 0.0027\left(1 + \frac{3}{10 \times 0.656}\right) = 0.00393$$

and for a pipe 0.492 ft. diameter—

$$f = 0.0027\left(1 + \frac{3}{10 \times 0.492}\right) = 0.00435$$

As the air flowed through the pipes, the temperature rose 9° C., by conduction of heat through the walls of the pipe, which would

EXPERIMENTS ON THE RESISTANCE OF THE PARIS AIR MAINS.

Number of Experiment.	Distance. Feet. L	Initial Absolute Pressure. Pounds. P_1	Final Absolute Pressure. Pounds Corrected. P_2	Initial Velocity. Feet per Second. u_1	Mean Velocity. Feet per Second. u_m	Coefficient of Friction. f	Description of the Pipe Line.
1	54278	106.6	86.15	24.69	27.20	0.00229	Entire Pipe Line.
2	54278	114.4	87.25	23.09	26.02	0.00316	" " "
3	54278	119·4	105.36	17.82	18.90	0.00280	" " "
4	54278	116.1	109.44	13.31	13.70	0.00253	" " "
5	54278	114.1	110.42	10.99	14.25	0.00212	" " "
6	14467	116.1	112.65	16.55	16.79	0.00323	Rue de Charoune.
7	14467	119.4	117.32	10.83	10.92	0.00445	" " "
8	14467	114.4	107.23	23.09	23.81	0.00344	" " "
9	14467	119.4	114.34	17.82	18.20	0.00395	" " "
10	10982	102.9	100.50	20.68	20.92	0.00214	Fontaine: Sta. 1
11	28776	112.5	109.87	13.71	13.87	0.00187	Charoune: Fontaine
12	10982	107.7	107.20	14.31			Fontaine; Sta. I
13	14520	113.9	111.01	14.40	14.58	0.00364	Station 1;
14	14520	108.3	106.64	16.06	16.18	0.00181	Rue de Charoune,

d = 0.980 feet.

Mean............0.00288

have the effect of reducing the value of *f* slightly. The results clearly show a reduction in the co-efficient as the diameter of the pipe increases, and with the larger pipe the co-efficient diminishes slightly as the velocity increases. These experiments seem to merit a good deal of confidence on account of the large scale on which they were made and the care that was taken to reduce the errors.

Weisbach's Experiments.

Quoting again from Prof. Unwin's paper:

"The great influence of the diameter of the pipe on the co-efficient of friction seems also to explain the differences between Stockalper's results and those of Weisbach. Weisbach had given for the co-efficient of friction of air values ranging from 0.012 to 0.028, or values from four to seven times as great as those obtained by M. Stockalper. Weisbach's experiments were made in small tubes about 2 metres long, at velocities of 80 to 490 ft. per second, and therefore the results do not merit great confidence. Still, if the very small diameter of the tube is allowed for, they diverge much less from M. Stockalper's results than they appear to do at first."

The following are some of Weisbach's results:

	Diameter. Feet.	f
Brass and Glass Tube	0.033	0.014 to 0.027
" " " "	0.047	0.012 to 0.026
Zinc	0.080	0.013 to 0.023

By the Unwin formula

For d = 0.033	f = 0.0272
d = 0.047	f = 0.0199
d = 0.080	f = 0.0128

Riedler and Guthermuth's Experiments.

A most important series of experiments on the resistance of the Paris air mains was made by Professors Riedler and Gutermuth. They merit especial attention because of the large diameter and great length of the pipes. The volumetric efficiency of the air compressors was first determined and then the quantity of air delivered to the mains was computed from the number of revolutions of the compressors. The pressure was measured at several points along the mains. It was necessary to make corrections for leakage and for the resistance of draining traps, draining tanks and stop-valves. Prof. Unwin has reduced these experiments to English units and made the corrections.§ The table on page 4507 contains the results of his computations. The diameter of the pipes was 30 c.m., or 0.98 ft.

Siemen's Experiments.

Dr. W. Brix describes a series of experiments made by Dr. Siemens: Sufficient data is given to enable us to compute the co-efficients of friction, although they do not merit much confidence, for the experiments were not made with much precision.

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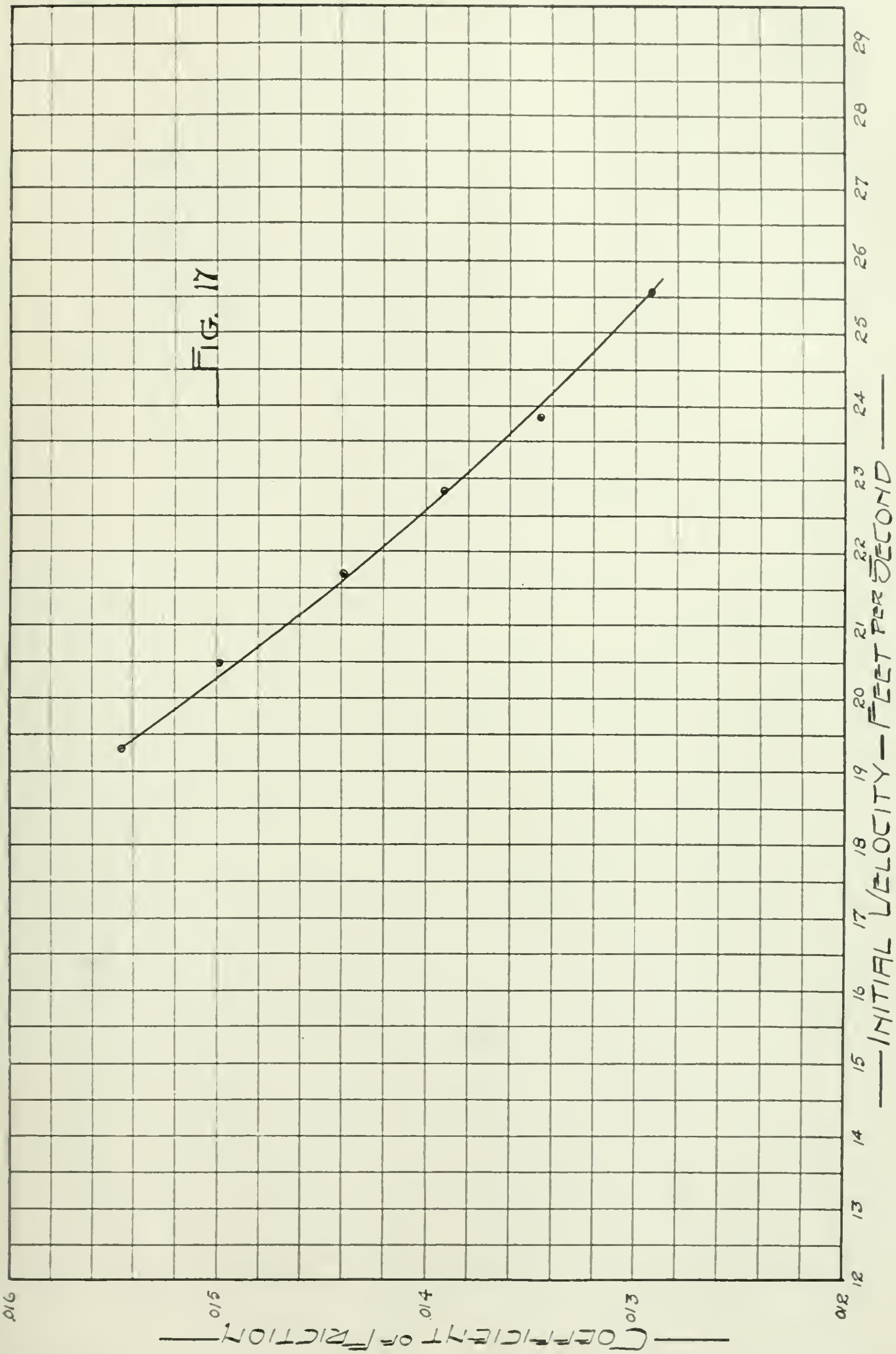
§"On the development and transmission of power." Unwin; p. 219.

FIG. 17


INITIAL VELOCITY — FEET PER SECOND
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
COEFFICIENT OF FRICTION
.016
.015
.014
.013
.012

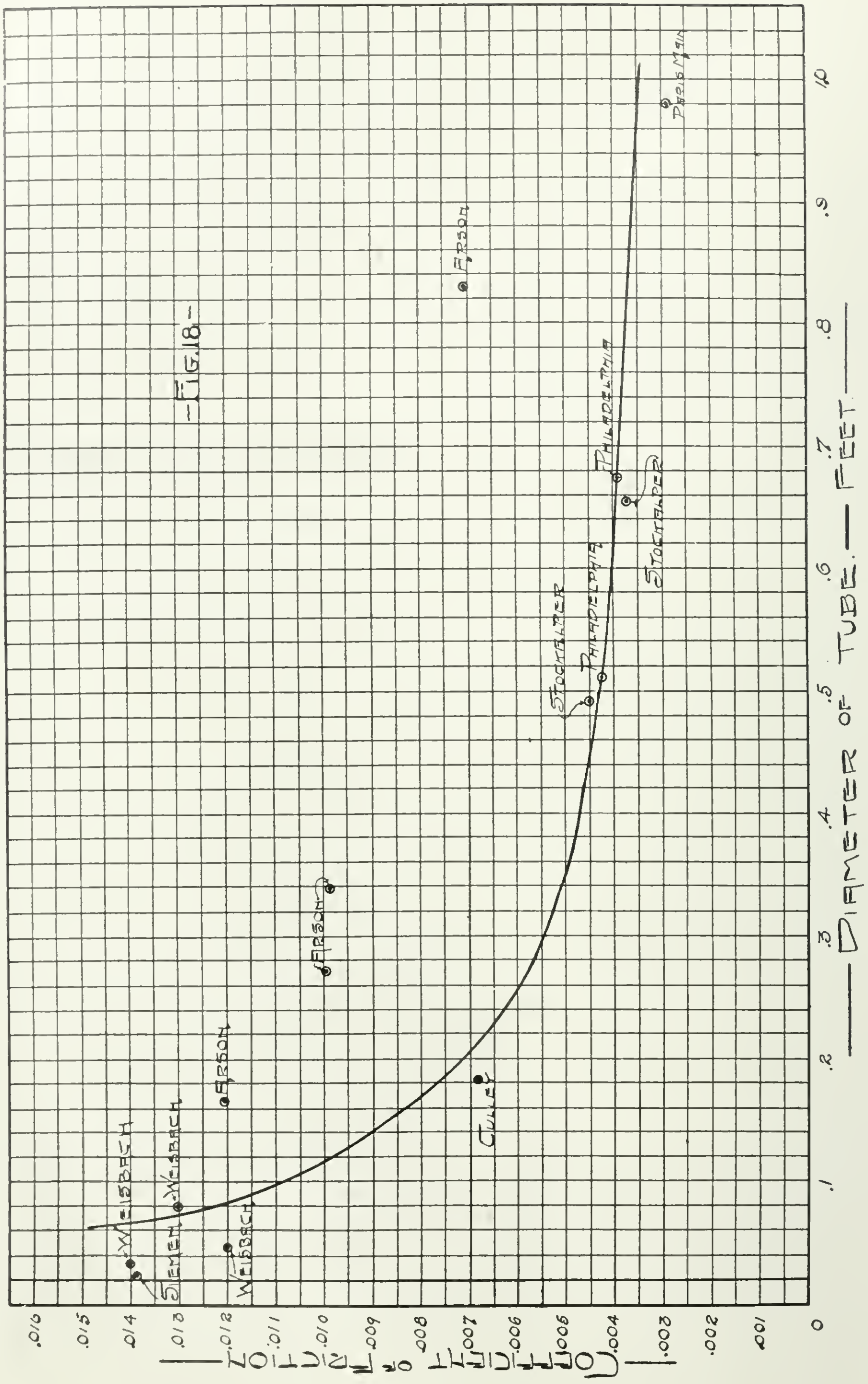

WEISBACH
SIEMENS
WEISBACH
WEISBACH
ARSON
ARSON
CULLEY
STOCKALPER
PHILADELPHIA
PHILADELPHIA
STOCKALPER
ARSON
PARIS MAIN
.016
.015
.014
.013
.012
.011
.010
.009
.008
.007
.006
.005
.004
.003
.002
.001
0
COEFFICIENT OF FRICTION
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
DIAMETER OF TUBE. — FEET

FIG. 18

STOCKALPER'S EXPERIMENTS.

	d	L	W		P	P	T	
Experiment.	Diameter of the pipe, feet.	Length of Pipe, Feet.	Weight of Air Flowing per Second, Lbs.	Mean Velocity, Ft.	Pressure at Beginning of Pipe, Lbs. per Sq. Ft.	Pressure at End of Pipe, Lbs. per Sq. Ft.	Mean Absolute Temperature.	f
I.	0.656	15092	2.669	19.32	11.852	11.090	531	0.00347
	0.492	1713	2.669	37.14	11.090	10.582	540	0.00450
II.	0.656	15092	1.776	16.30	9.207	8.741	531	0.00366
	0.492	1713	1.776	30.82			540	
III.	0.656	15092	1.483	15.58	8.217	7.725	531	0.00410
	0.492	1713	1.483	29.34	7.725	7.503	540	0.00447

Mean coefficient for 0.656 ft. pipe 0.00374.
" " " 0.492 " " 0.00419.

The method of making the experiments was to maintain a constant pressure in a tank and allow the air to flow from the tank through an experimental tube, then through a gas meter into the atmosphere. The pressure was observed and the quantity of air flowing was measured by the meter. No temperatures are recorded. The tubes were of lead.

The second table on page 4507 gives some of the results reduced to English units, with the values of **f** computed.

These results are interesting because they show a remarkably uniform variation of the co-efficient with the velocities, made even more apparent by plotting them and drawing a curve as has been done in Fig. 17. The values of **f** are about one-third the value obtained from the Unwin formula, but the tube was extremely small, so it is quite possible that the formula does not give correct values in such an extreme case.

Conclusions.

After a careful study of the results of all these experiments, we seem to be justified in drawing three conclusions: First, the co-efficient of friction varies with the diameter of the tube; second, Prof. Unwin's empirical formula expresses the relation of the co-efficient to the diameter of the tube as accurately as it can be stated until we have more experimental data; third, the co-efficient of friction probably varies with the velocity of the air.

The results of all the experiments are plotted in Fig. 18, and the curve of the Unwin formula is drawn with the same coördinate axes to show how closely the curve fits the experiments. The ordinates are values of **f** and the abscissa diameters of tubes. The Paris, Philadelphia, Stockalper and Culley-Sabine experi-

SIEMEN'S EXPERIMENTS.

No. of Experiments.	Initial Absolute Pressures Inches of Mercury.	Final Absolute Pressures Inches of Mercury.	Final Vecocity Feet per Second u_2	Initial Velocity Feet Per Second u_1	Coefficient of Friction **f**
16	36.22	29.86	23.28	19.33	0.01543
18	37.00	29.86	25.34	20.49	0.01498
20	37.79	29.86	27.40	21.69	0.01440
22	38.58	29.86	29.46	22.84	0.01387
24	39.37	29.86	31.42	23.87	0.01345
26	40.15	29.86	33.17	24.72	0.01322
28	40.94	29.86	35.02	25.59	0.01292

L = 358.4 d = 0.02146

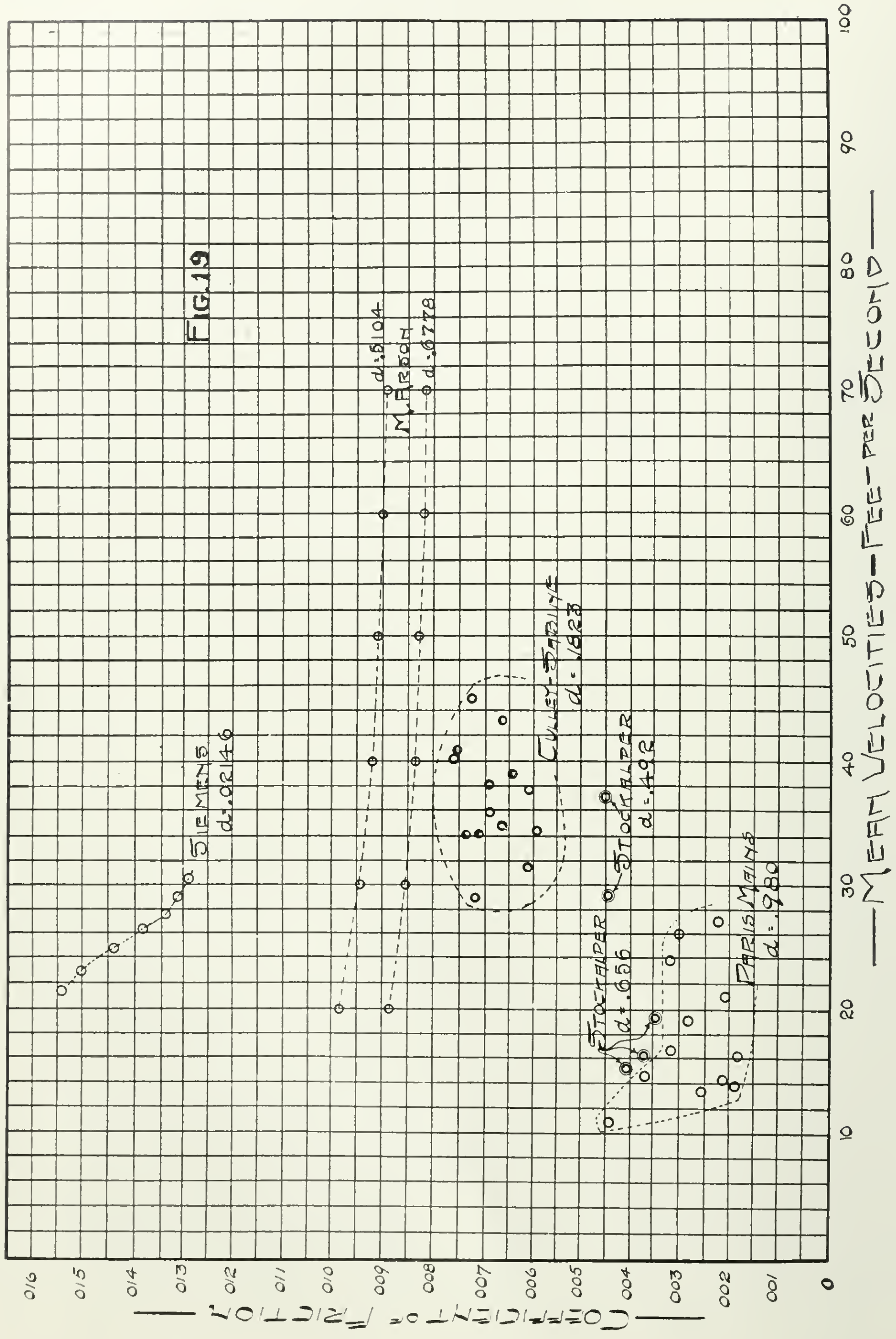


FIG. 19

SIEMENS
d. .02146
d. .5104
M. ARSON
d. .6778
CULLEY-SABINE
d. .1823
STOCKALPER
d. .492
STOCKALPER
d. .656
PARIS MAINS
d. .980
—MEAN VELOCITIES—FEET PER SECOND—
10
20
30
40
50
60
70
80
90
100
—COEFFICIENT OF FRICTION—
.016
.015
.014
.013
.012
.011
.010
.009
.008
.007
.006
.005
.004
.003
.002
.001
0

ments lie most nearly on the curve, and they are probably the most reliable. Perhaps if all the results could be reduced to a common velocity they would lie more nearly on the curve.

The value of **f** varies much less with the velocity of the air than with the diameter of the tube; therefore, experiments of a higher degree of precision are required to show the former relation. Besides my experiments in Philadelphia, the experiments of MM. Arson and Siemens clearly indicate such a relation. Stockalper's results show a tendency in this direction, and it requires only a little stretch of the imagination to see the effect of velocity in the experiments with the Paris mains. Culley and Sabine's results do not throw much light on the subject, since they extend over such a limited range of velocities. No doubt all of these experiments would have shown a variation of the co-efficient with the velocities had the range of velocities been greater.

The results are all plotted to the same scale in Fig. 19., with values of **f** for ordinates and velocities for abscissa, showing at a glance what each contributes.

This is a fruitful field for research, and it is to be hoped that other investigators will give us more light on the subject.

(*The End.*)

LIQUID AIR IN METALURGY

It is generally assumed that at very low temperatures metals become brittle and even fragile, and in numerous cases the breaking of steel rails in winter weather has been attributed to this cause. By the use of a bath of liquid air it has been found practicable to test various metals and alloys at temperatures as low as—180° C., and this has led to the discovery that while many steels have their tensile strength increased, their ductility lowered and their brittleness raised at low temperatures, this is not always the case. R. A. Hadfield, a well-known British metallurgist, has shown that a nickel manganese steel can be made which will be as tough, if not tougher, at—180° C. than it is at ordinary atmospheric temperatures, and this, too, without material change in tensile strength. Liquid air has also been used for quenching specimens after tempering, and some instructive information has been obtained about the process of hardening in this way.

THE PROPER INSTALLATION AND USE OF COMPRESSED AIR IN RAILWAY SHOPS AND MANUFACTURING ESTABLISHMENTS*

By W. P. Pressinger.

During the last five years much progress has been made toward the standardizing of operations with air tools, hitherto accomplished by different means in different shops; also, we are witnessing the realization of prophecies regarding the extension and wide-spread use of air-power which seemed wildly extravagant when they were made. From the air-brake pump to the Corliss compressor is a wide reach, yet many have seen their air-power plant develop from one to the other during the past ten years.

I shall merely mention in passing the familiar applications of the air hammer for chipping, riveting, scaling, or any service demanding a rapid, hard, percussive blow; the air motor for drilling, reaming, flue rolling, turning car journals, or any kind of work requiring rotative power; the air hoist, either in the form of a motor or a straight-lift cylinder and piston. Likewise may be mentioned the pneumatic jack, the sand blast, the stay-bolt nipper, the paint burner and the paint sprayer, the air-cleaning nozzle and numerous other special uses devised for this readiest of powers.

The application of compressed air for raising water from bored wells represents a steadily widening field in which compressed air has no rival. Especially is this form of compressed-air usefulness coming into more general service with railroads; not only does the air lift yield more water with less power expenditure, but the possibility of producing compressed air at one power plant and conveying it without appreciable loss to as many pumping points as desired, entirely eliminates the cost and maintenance of the separate pumping plant at the well.

Electricity is the desirable long-distance transmitting agent, and as such is employed to a wide extent in utilizing distant water powers for compressing air at the operating point for driving drills, hoists, pumps, etc. Similarly in industrial plants of large area, motor-driven compressors may be found distributed at points of chief consumption, the transmission of the electric current being preferable to the initial cost, inspection and maintenance of long-distance air mains. Many main power plants have large compressors motor driven when conditions favor this form of drive.

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*Abstracted from Proceedings of Central Railway Club.

Therefore, in its own unique field, by reason of properties peculiarly its own, compressed air remains in undisputed possession.

Forcing recognition in the beginning by reason of their wonderful labor economies, air tools have gained an established place, not originally conceded, partly because of the great strides accomplished toward higher efficiency in the selection and installation of compressed-air plants.

It is natural to expect that larger compressing units would produce compressed air with less relative expenditure of power, since the opportunity exists for refinements of design and construction not possible in the smaller compressors. But so great has been the demand for a reduction in the cost of compressed air production that contemporary compressors in all sizes are vastly superior to the earlier patterns in use when air tools were first introduced. This has been accomplished through an intelligent appreciation by the builders of air-compressing machinery of the more arduous service which compressors undergo, to which they have responded by designing machines adequate in weight, strength, bearing surfaces, valve areas and automatic regulation, to the severer conditions. Users of compressed air in the selection of their compressors have contributed an influence equally beneficial by exercising a discriminating knowledge and judgment (expensively obtained in the school of experience) which they did not possess when compressors first supplanted air-brake pumps.

An evil to which not overscrupulous compressor builders have contributed is the overrating of compressor capacities. As is well known, compressors are rated according to their piston displacement, this being the cylinder area multiplied by the piston speed. From this result deductions due to clearance losses and heat expansion must be made to arrive at the actual volume of air delivered. These losses necessarily vary according to the style of the machine, emphasizing the inevitable conclusion that greater initial investment pays a handsomer dividend.

Beyond an arbitrary limit, however, compressor ratings at high speeds mean nothing but deception, since greater displacement than the air valve area permits is not possible, even if structural strength and bearing surfaces are adequate, which they rarely are. Experienced compressor users realize thoroughly the desirability of providing machines of size sufficient to deliver the requisite yield at moderate working speed, reducing cost of maintenance and greatly prolonging the life of the machine.

But while these recent prosperous times have enabled a great betterment of compressor equipment, there is much yet to be accomplished. There still remain air-brake pumps in use supplying shop requirements, and plants with compressors inadequate or obsolete, or both, are still altogether too numerous. An investigation applied to individual conditions would develop results so surprising as to overcome all ordinary objections to the increased investment, and instances where compressors have been shown to earn their cost within one to two years after installation are by no means rare.

For railroad shops and industrial establishments the steam-driven compressor is, of course, most generally employed, though many more motor-driven compressors are used than formerly, conditions being favorable. The demand is steadily growing for compressors of moderate capacity for use where steam to drive them is not available. Motor-driven compressors meet this requirement if electrical current is obtainable and gasoline engine driven compressors where neither steam nor electricity may be had. Such machines are highly useful for maintenance of way and bridge construction and for repairs at junction points. The necessity of testing the air-brake equipment of cars received from other lines has also created a considerable demand for self-contained gasoline driven compressors with engine and compressor mounted upon one bed, the engine driving the compressor by gear or silent chain.

Compressors up to 200 cubic feet per minute capacity for a terminal air pressure of 100 pounds per square inch are usually of the single-cylinder type, double acting. Above 200 cubic feet per minute two-stage compressors show an economy that should not be disregarded. Formerly duplex compressors having two simple compressing cylinders were common, but except for low-air pressures, which do not warrant compounding, these have been superseded by the two-stage type.

The power saving effected through two-stage compression is illustrated in the subjoined table showing the horse-power required to compress 100 cubic feet of free air per minute from atmospheric pressure to the various pressures stated:

Gauge Pressure Pounds	One-stage Compression D. H. P.	Gauge Pressure Pounds	Two-stage Compression D. H. P.
10	3.60	60	11.70
15	5.03	80	13.70
20	6.28	100	15.40
25	7.42	200	21.20
30	8.47	300	24.50
35	9.42	400	27.70
40	10.30	500	29.75
45	11.14	600	31.70
50	11.90	700	33.50
55	12.67	800	34.90
60	13.41	900	36.30
70	14.72	1000	37.80
80	15.94	1200	39.70
90	17.06	1600	43.00
100	18.15	2000	45.50

The above table does not take into consideration jacket-cooling or friction of machine. Initial temperature of air at beginning of each compression is 60 degrees.

Steam cylinders are compounded generally when the steam pressure at throttle is sufficient to warrant. The limit of capacity at which the Corliss steam end should supplant the slide valve varies according to the appropriation available and the cost of fuel. Corliss compressors of 1,500 and 2,000 cubic feet per minute capacity are much more frequently installed than formerly.

After determining the important element of compressor selection, much can be accomplished in the direction of intelligent installation. Proper compressor location, a well-planned air-pipe system of adequate proportions, appropriate size and location of air receivers, provision for moisture drainage, systematic inspection to locate and stop air leakage, air hose of good quality, tight, quick-acting couplings, are all features which contribute to ultimate efficiency.

Since the atmosphere that we breathe is *free*, its value when compressed, represented by the cost of maintenance of plant and power expended in compressing it, is too lightly regarded, with the result that it becomes a favorite means of blowing dust from machines, work benches and garments, and a plaything in the hands of the mischievous, frequently with dangerous and sometimes with fatal results. For cleaning armatures and delicate machinery compressed air is often an indispensable agent, but strict orders and severe penalties should prevent its indiscriminate and unauthorized waste.

Trouble from the presence of moisture in compressed air is now infrequent, and is readily avoided by effectual cooling after compression, similar to the treatment provided for switch and signal installations.

Dirt and grit in compressed air clogs the necessarily delicate working parts of pneumatic tools and the inevitable excessive wear on valves and other parts causes rapid depreciation in value and power. To avoid this it is desirable to screen or filter the air at the compressor intake, but care must be observed not to have the screen of too fine a mesh or the air supply will become partially throttled. Occasional instances have occurred where compressor capacity has been markedly curtailed from this cause. As most of the air tools now sold are also provided with individual strainers, trouble from dirt in the tools is not frequent. These strainers also must be kept clean or the tool will appear to have lost its power.

The lubrication of compressors and pneumatic tools is a feature deserving careful attention. A too frequent mistake is made by using in air cylinders of compressors oil intended for steam cylinders. Such oil is of low flash point, whereas, the power lubrication of air cylinders demands a light oil of high-flash point and of very best quality. Oil of poor grade and low-flash point becomes vaporized in air cylinders and is discharged with the air without effecting lubrication.

Oil should be fed to air cylinders slowly and sparingly, as too much oil will clog the air valves, causing them to stick and give trouble. Air valves should be examined and cleaned at intervals by washing in kerosene or naphtha. When this is done the valves should be removed from the compressor. Engineers have been known to introduce kerosene through the air-inlet pipe, an effective method of cleansing dirty valves, but sometimes equally effective in producing an explosion, since the oil forms a fine spray or mist which, when compressed with the air, produces a condition similar to that in the cylinder of an oil engine.

The plan of feeding soap suds into the air cylinder through the lubricator is excellent for keeping valves clean, but when this is done oil should be fed through afterward to prevent rust.

The lubrication of pneumatic tools is of equal importance. One cannot do better than obtain and use one of the several brands of oil furnished by pneumatic tool makers who have made a special study of the requirements. Such oil is necessarily light, and under no circumstances should a heavy oil be used, as the cooling effect of the expanding air would cause it to clog the tool parts and prevent the free movement of the parts.

Pneumatic hammers should be carefully cleaned after using and kept submerged in a tank of oil when not in service. An excellent device for effectively lubricating pneumatic tools is an automatic oiler inserted in the supply hose about twenty inches from the tool, with oil-proof hose between oiler and tool, which, operating on the principle of an atomizer, enables the flow of the lubricant to be regulated to a nicety.

Unlike electricity, compressed air has worked out its own destiny in the hands of practical men, unaided by special technical courses at institutions of learning, and the results accomplished, as represented by the important position it now occupies, are the final word in behalf of this highly useful power.

POWDER IN BLASTING

Powder is an important item of expense in a mine, and much of it is generally wasted. Lack of facilities or wilful neglect in thawing frozen powder cause the inefficiency of much that is used. When frozen its rock-breaking force is much diminished, and it is vastly more dangerous to handle. Miners will often take a stick of giant powder frozen as hard as a rock and break it in two with their hands. It can be safely thawed by placing in tubes and standing in water heated to the right temperature. If there is no other means of thawing it handy, sit on it a bit.

Don't use too much powder in charging. Holes are often charged to the collar; a good miner, one who breaks the most rock, will charge his holes only about one-half, and a hole thus loaded will "break" as well and with much less gas than when loaded to the collar. The gases generated by the powder are rightly dreaded by the miners, and this excessive generation of gas is about the only additional result obtained by ramming a hole full of powder, or, as is common, by tamping it with powder.

There is some question whether the primer should be put in first in the bottom, in the middle, last, or where. It is really immaterial, for it will explode the powder as well in the bottom as in the middle. It might be possibly safer to put in the primer last, as it would not then be subject to so much tamping, but with an inferior quality of fuse, there might be less chance of a "burnt hole" if it were put in the bottom. In wet holes, to avoid misfire, it is best, even after having well greased the primer, to put it in last.

If a stick of powder is more than is needed, it should be cut in two with a knife, not broken. While the use of too long a fuse is not to be especially censured, the excessive use of powder, besides being wasteful, is the cause of many a "powder headache," and has caused more serious consequences, due to the gases thus generated, where there is a poor circulation of air.

TOUGHER THAN ELECTRIC DRILLS

Electric drills will be used in the development of the West Hecla group at Burke, Idaho. The machinery has been ordered. The power will be furnished by the Washington Water Power Company, a line being run from the station at the Hecla mine.—*Mining Review.*

The drills here referred to are as different as possible from electric drills, being in fact Electric Air drills. The first one, already successfully at work, was sent forward by express and on the way was dumped into the river. The motor was thoroughly water-soaked and filled with coarse white sand, a lot of water got into the air cylinders and one or two small parts had to be replaced. The report from the mine was that "after drying out the motor we took it up to the mine, and upon connecting it found that it started off without a hitch."

When speaking of these drills, it is quite important to remember the air, which is the only actuating agent in the drill itself and entirely transforms it from the discredited electric drill.

THE "SAND HOGS"

The following interesting story from a Philadelphia daily contains a variety of information, some of which our readers will accept as familiar, while other portions will be news to them:

"Men engaged in caisson work are veritable human soda water fountains," remarked the contractor.

Yet a pressure of thirty pounds to the square inch is not the limit. A pressure of fifty pounds is often applied. Industrial ambition does not even end there. It is proposed to test man's resistance to a pressure of 100 pounds to determine the feasibility of an attempt to tunnel beneath ocean waters.

Every man who sticks to the work, a contractor says, is broken down sooner or later. Many of the deaths are attributed in the physicians' reports to other diseases, but it was the compressed air, doubtless, that aggravated, perhaps caused, the diseases. Although it is not a matter of common knowledge, this great danger of working in compressed air is well known to the "sand hogs" themselves. It doesn't alarm them.

"Why do they stay in the business?" was asked.

"The money is what holds them," he explained. "A day laborer usually makes $1.50 to $1.75 a day. These caisson workers, who are fitted only for laboring jobs, get $3 to $4 a day, according to the amount of pressure they work in."

But it is not entirely the danger which determines the "sand hogs'" wages. Mr. Hollingsworth avers that of fully as great consideration is the fact that a "sand hog" does twice as much work as an outside laborer—*the compressed air in his system makes him feel so strong that he cannot work slowly.*

Eighteen "sand hogs" are employed on the Rapid Transit Company's caisson. Six work at a time, and the day is divided into three eight-hour shifts. For eight hours, excepting a half hour for lunch, a workman breathes only air which is forced into his lungs at a pressure of ten to fifty—usually about thirty—pounds to the square inch.

Of the 20,000 men employed in the work in various parts of the country, only about 5000 are professional "sand hogs," so that the ranks must be recruited constantly from green hands. An applicant is carefully examined by a physician, and if he has weak heart or lungs, or suffers from any chronic ailment, he is rejected. Those accepted enter the caisson at their own risk. Despite careful examination, a constitutional defect undiscovered by the physician often results in death.

To avoid laying the foundation of its proposed coaling station on quicksand, the Philadelphia Rapid Transit Company was compelled to sink two caissons down to rock bottom, forty feet below the surface of the ground and twenty-five feet below the bed of the Delaware. Upon them concrete corner foundations will be built. A box the dimensions of the foundation—in this case 22 by 32 feet—is built of Georgia pine planks laid over one another to a thickness of two and one-half feet, and made watertight by caulking. The height of the box is eight feet. Inverted, the box is sunk to the bottom. From two circular holes in its roof iron stacks rise upward. In the box all is airtight, and would be dark but for the electric lights provided.

As the hole sinks deeper in the sand of the river bed sections are added to the stacks, and the caisson box continues going lower as the excavation progresses. At a depth of thirty to forty feet the operations are most interesting, because then the battle between compressed air and river pressure—with human beings between the two forces—is at its height. Air is compressed in an engine house nearby and fed to the caisson through the two stacks. One stack is for freight, the other for passengers.

Calculating always on twice as much air pressure as the head of water—this to keep the water back while "sand hogs" burrow deeper into the ground—one who now enters that hole is subjected to thirty pounds of air pressure to the square inch of his body.

You climb a ladder to the top of the passenger stack, and the operative pulls a heavy lid up to let you in. You find yourself on a platform; the lid is closed over you. Two little candles flicker away at your feet to aid your courage. This, the guide tells you, is the critical stage—it is here that you are to be charged with compressed air. A valve is opened in the platform beneath you, and "siz-z-z" the air comes up and gradually envelops you. It condenses the other air to a fog. A roaring, like that of distant waters, is in your ears; then total deafness; then a feeling as though your jaws were locking and your throat drying to crisp—which is overcome as soon as you succeed in swallowing—and then you feel all right—if you have not already collapsed.

It took three minutes to charge you; it seemed fully three hours. This had to be done gradually, or you could not have stood it with all your good constitution.

A lid is raised from the compartment under you; you descend a ladder to the sand bottom where six men are digging and shoveling away with a merry will. You are told that this quicksand would swallow you in a half hour but for the compressed air, *which hardens it so that it can be worked in.*

Returning, you must wait in that upper chamber until the compressed air is gradually drawn from you—an operation much slower than that of charging you. What if one should come immediately into the outer air? The "bends."

Dr. Hill and Professor MacLeod, two New York experts, believe it will prove practicable to go 200 feet below water level, and to use air pressure of more than 100 pounds to the square inch, if picked men are employed and if two hours are devoted to the liberating stage.

He who succumbs to heart failure usually drops dead in the caisson. Gruesome spectacle for his fellow-workers, yes; but they think of that $3 a day and keep on working. Sometimes it is only paralysis, and this may possibly be cured by "frying out" the victim—that is, *by placing him in almost boiling water for an hour or two.*

USES OF COMPRESSED AIR IN A SHIPYARD

Mr. James L. Twaddell, speaking before the Northeast Institution of Engineers and Shipbuilders, mentioned some of the incidental and unfamiliar uses of compressed air, as follows:

We have had a compressed air wood deck caulking machine, and we are now caulking a ship's teak deck with it, and it is doing excellent work. As compared with the ordinary style of hand caulking, we find—to put the case very fairly indeed—that in the hands of one man it does the work of four easily, but in many cases we have had far more than that out of it. In regard to the wood deck planing machine, that also emanated from our works, and it is a complete success. It is a much better machine than the electrical one, and the exhaust air clears its own track by blowing away the chips from the deck. As compared with handwork, there is no comparison at all. With the pneumatic machine you get a surface almost like that of a billiard table, whereas you get no regularity with hand-planing unless you go over it many times.

We have used pneumatic tools for distributing ground cork on the surfaces of war vessels, and also in covering the cork surfaces with paint, which takes a very great deal of hand labor when done with the brush. By distributing it with the compressed air the paint is put right into the rough surface with one coat, and the compressed air device does not use any more paint. It is a simple contrivance, something like an ejector.

We have found in many instances that compressed air can be used instead of steam. For instance, we have had lying at our finishing jetty a vessel with auxiliary machinery on board, but no steam near. We have applied the pneumatic power to auxiliary pumps, simply coupling up the compressed air and using it instead of steam. By this means we have also run an electrical plant all night. I mention this only to show the various uses that compressed air can be put to. In fact, the more I see of its usefulness the more I am surprised it has been so long in coming, and that so few have taken it up now it has come. I consider the adoption of pneumatic plant in shipbuilding yards one of the finest things that has happened during the last ten or fifteen years in shipbuilding. It is a matter of such wide interest that people have only got to see it to be convinced of its utility.

COMPRESSED AIR IN IRON FOUNDRY

Compressed air is now used in the large iron foundry at the Schenectady works of the General Electric Company for almost every operation connected with the making of a finished casting. Although the machinery in the other adjacent shops is operated entirely by electricity, in the iron foundry, where the operations are scattered and intermittent, compressed air was found to be advantageous for small power services. The air is supplied at 80 lbs. pressure by a number of electric motor-driven compressors of different capacities.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

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FRANK RICHARDS, Mem. A. S. M. E., Managing Editor
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COMPRESSED AIR TO MAKE SHIPS SAFE

A writer in a recent issue of the *Scientific American* offers an important suggestion concerning the saving of ships by the use of air, arguing that provision should be made for it in the design and construction of steel vessels generally. No radical changes and no heavy outlays would be involved. He writes:

"I would suggest, in the first place, that the main deck or first deck above the load waterline of every passenger steamship, battleship, and cruiser should be built airtight, and of sufficient strength to sustain a pressure of air below that deck that would keep the vessel afloat, even if the bottom were perforated in every compartment. That would mean, of course, that the deck would have to be so built that every opening could be hermetically sealed, so to speak, and in the shortest possible time. Each compartment should be separate and independent of the other. Each of the compartments should have an airlock, on the same principle as those used in the construction of the North and East River tunnels in New York City. A gang of locomotive air-brake pumps should be installed above the safety deck, operated by gasoline motors, so that they would be wholly independent of the ship's power—of sufficient capacity to fill any one or all the compartments with air within a short space of time. By these means, easy and safe access could be obtained to any compartment, and repairs made to the damaged part of the vessel. Further, each one of the compartments should be supplied with an electric light system and a telephone system, controlled and operated from a central point. A vessel equipped in this manner would be practically unsinkable, unless broken in two or the plates strained in every part of the ship so that the air pressure could not be maintained; and even in the former case, if each half of the vessel had its full complement of air pumps and other appliances, the two halves could be kept afloat independently, but, of course, the propelling power would be available only in one portion. The additional expense entailed by this mode of construction would be comparatively small.

"Take the case of the Allan steamship *Bavarian,* recently floated in the St. Lawrence River by means of pneumatic pressure. The cost of the vessel was over $1,000,000. She was sold by the underwriters, I understand, for about $30,000. That amount, I estimate, would fully cover the cost of installing the appliances I have suggested herein; but assuming it would be $100,000, it would be well worth expending to insure the safety of a vessel of that class. No vessel, large or small, that traverses the ocean is immune from danger by striking derelicts, icebergs, collision with other vessels, or running aground in foggy weather or in heavy snowstorms, when lights are obscured and the reckoning can not be ascertained, in approaching a dangerous coast.

"Provision should also be made for the installation of check valves, relief valves, and air gauges both inside and outside of each compartment, in order that persons working under air pressure could regulate the supply of air as circumstances might require. It would appear to me that sliding doors should be used, instead of swinging doors, in all partitions below the airtight deck, and that these doors should be kept closed except when not actually in use, and that horizontal sliding doors should be used to close apertures or hatches in the safety deck. A system of indicators might be installed in the central telephone and electric light switchboard room which would show, at all times, the position of the vertical and horizontal doors in each compartment; that is, whether they were open or closed. I have not gone into any calculations with regard to the air pressure that would require to be developed, but I would estimate, roughly, that it would be very much below 30 pounds to the square inch."

The writer evidently is not fully informed, and does not claim to be, as to the details of modern marine construction or of general engineering practice. The suggestion as to the employment of air-brake pumps is, of course, absurd. There are gasoline-operated single-stage air compressors which would be very suitable for this service. They would not be bulky or costly, would be always ready and would work with reasonable economy.

It will be remembered that the January, 1907, issue of Compressed Air contained a graphic description of the raising of the *Bavarian*, above referred to.

COMPRESSED AIR FOR REFRIGERATION.

Mr. Sydney F. Walker, Bloomfield Crescent, Bath, England, contributes to *The Engineering and Mining Journal* an interesting and valuable article upon the "Mechanical Production of Low Temperatures," discussing the principles of refrigerating processes which may be used for cooling deep workings and in shaft sinking by freezing.

The use of the freezing process, he says, for sinking shafts is steadily increasing, and the problem of the increased heat at the continually increasing depths to which both coal and metalliferous mines are being sunk is gradually rendering the problem of the mechanical production of low temperatures of increasing interest. Refrigeration and the artificial production of ice have been in vogue for about twenty-five years. Broadly stated, the mechanical production of low temperatures is dependent upon the ability to convert certain substances from the gaseous to the liquid state, and their return to the gaseous state, by the abstraction of heat from the substances to be cooled. The process consists practically in abstracting the heat from the substance that is to be cooled, and transporting it to the cooling water of the condensing plant.

There are three substances now employed that can be converted from the gaseous to the liquid state, and *vice versa*, with comparative ease, viz., ammonia, carbonic acid and sulphurous acid. Other substances have been employed. Ether, for instance, was employed somewhat largely in the early days of mechanical refrigeration, and is still to a certain extent in India, owing principally to the very low pressures required. Compressed air has also been employed, and is still to a certain limited extent, but compressed air is very much less efficient than either of the other refrigerants named, mainly because, owing to the large power required, no attempt is made to liquefy it. It is merely compressed to a certain pressure, cooled, dried, and allowed to expand.

Probably compressed air will be found to be the readiest agent for dealing with the high temperatures met with at great depths in mines, since the whole apparatus can be installed underground, and run by an electric motor.

In view of the possibility of compressed air being used for lowering the temperature in the workings of deep mines, or for similar purposes about a mine, it may be useful to shortly describe the apparatus. It consists of the usual air-compressing cylinder, with its reciprocating piston, and an expanding cylinder, which also has a reciprocating piston, the two pistons being connected to the same crank shaft, their cranks being usually 90 deg. apart.

Cooling and drying apparatus of various forms completes the plant. One form consists of a cylinder, nearly filled with glass marbles. A fine spray of water is delivered to the top of the mass of marbles, and gradually trickles down over them, passing through the interstices between them, and the air to be cooled enters the cylinders at the bottom, passing up over the surfaces of the marbles, meeting the spray of water, and being cooled and depositing its moisture.

From the cooling cylinder, the air passes into the expanding cylinder, where it works the reciprocating piston, the work performed upon this piston going to assist the work of the engine or motor driving the compressor, the motor thus having only to supply the difference between the two.

In the expanding cylinder the air is cooled to whatever temperature may be desired. It is claimed by makers that it is cooled to as much as 100 deg. below the freezing point. From the expanding cylinder, the cooled and expanded air is driven into the chamber or other place to be cooled, and in regular cold-storage work is usually drawn off again by means of a duct, provided for the purpose, to the compressor, recompressed, recooled, expanded, and so on.

The great source of loss, quite apart from the inefficiency of the method of compressing and expanding the air, is that by conduction through the walls of the pipe, or duct, through which the cooled air passes to the chamber or object to be cooled. This duct is made as short as possible, and it is also well insulated thermally, but in spite of that, considerable loss too often results.

Another method is that employed in the Allen dense-air machine, made by H. B. Roelker, of New York. In this apparatus there are two important points of difference from that previously described. The air, after being cooled, is carried in small pipes into the space to be cooled, much in the same way as the ordinary refrigerating agent, ammonia or carbonic acid, is, and it is brought back, after circulating through the grid of pipes, to the compressor, the grid of pipes in which the air circulates corresponding to the expansion coils of the ordinary compression or absorption apparatus.

In addition, the air is cooled on leaving the compressor, by being passed through a coil of copper tube, immersed in a cylinder, through which water is kept circulating. Further, the return air from the chamber that has been cooled is caused to cool the air on its passage from the cooling coil to the expansion cylinder, by circulating in pipes round which the air from the compressor passes, the arrangement being similar to that employed with cooling water and steam in the surface steam condenser. The apparatus has also an auxiliary air compressor, consisting of a small cylinder with piston and auxiliaries, the object of the arrangement being to charge up the system, when it is first put into service. The air, it will be understood, circulates continually round and round, through the compressor, the copper cooling coil, the returning air cooler, the expansion cylinder, the cooling coils, back to the compressor again, any loss being made up, when required, by the auxiliary compressor.

This apparatus appears to be very suitable for cooling the workings of deep mines, since the air-cooling pipes could be carried into the workings, and arranged in any convenient manner. One difficulty that will present itself to mining engineers is the possibility of breakage of the pipes. This could probably be overcome by the employment of flexible metallic tubes, either wholly or for connecting straight lengths of ordinary iron pipe.

FATAL EXPLOSION OF A MINE LOCOMOTIVE

A compressed air locomotive exploded with fatal effect on June 4 in Colliery No. 14 of the Pennsylvania Coal Company, near Scranton, Pa. The locomotive was drawing its last trip of cars for the day to the shaft. The pressure of air was low and a charging station being reached a little over half a mile from the shaft air was taken in at that point. The pressure in the tanks is stated to have fallen to about 200 pounds, while the permitted tank pressure was 600 pounds, a pop safety valve being set at that pressure. The pressure on the pipe line was 1000 pounds and when the gage on the locomotive showed 550 pounds and while the brakeman who did the charging was in the act of closing the valve the explosion occurred. Of the twin tanks on the locomotives one was broken mostly into small pieces. The other tank had one head and the end cylindrical section blown off, and the side of the tank was ripped. Many bolts and rivets were sheared as if by a machine. The metal all seemed to be perfect, and it was said that there was no sign of fire or of oil on the metal.

The locomotive driver and another man were killed instantly, and a third died soon after, while a number were severely injured.

In expressing some opinion as to the cause of this terrible and unusual accident we of course speak only tentatively and in the light of present information, which of course is not sufficient to warrant a final or authoritative determination.

From the force and the disastrous results of this explosion as narrated, it seems to us evident that it was not due to an excessive pressure of air or to the weakness of any part of the apparatus. We would say that it was undoubtedly due to the formation of an explosive mixture of air and oily vapor and then a sufficient temperature *at some spot* to cause ignition.

Although we have no record of an explosion quite similar to this, there is always a possibility of danger in the *rapid* recharging of an apparatus of this character. In this case the pressure was raised quite suddenly from 200 to 550 pounds. Neither figure may be the limit. In the body of either tank we may suppose that the incoming air mingled with that already in it with some rise of temperature but not enough to be dangerous in itself. Any portion of the original charge, however, remaining in any pipe, passage or pocket would not be mixed with the incoming air, but would simply be compressed from the lower to the higher pressure, and its temperature would be raised correspondingly, just the same as if it were compressed by a piston in a cylinder. If the temperature of the air at 200 pounds was 60 degrees its temperature at 550 pounds would be 233 degrees, which probably also could not be considered dangerous, although approaching the danger point.

As the last trip was being made and a number of men carried on the train were probably clamorous to get out, we may suppose that the recharging was done as rapidly as possible. The inrushing air was therefore heated by friction to a temperature not computable but evidently sufficient, in addition to the heat above stated for the compression, to cause the ignition. The air in its inrush also must have traversed some passages where oil had accumulated and some of this oil was vaporized and mixed with the air, and then both the explosive mixture and the ignition temperature were provided for the fatal catastrophe. We may suppose that the explosion when it did occur was of a mixed character. The explosive mixture did not fill both tanks, and probably only a portion of one of them, but its ignition began the work and probably did most of the damage, the suddenly released air which was not ignited following up with its tearing force until the pressure was gone.

EXPLOSION OF AIR RECEIVER

A vertical air receiver, 40 inches diameter and 10 feet high, recently exploded in the works of the Northwestern Thresher Company, Stillwater, Minn. The working air pressure was 100 pounds, and presumably this was the pressure when the explosion occurred. The seam connecting the lower head with the shell let go and the body of the receiver was thrown up against the roof, breaking two wood rafters 3" x 14" and cracking a 12" x 12" beam. A hole was knocked in the masonry foundation and two men were injured, one having been thrown upon a vise and the other against a planer.

This seems to have been a simple explosion, due to weakness at the point where the rupture occurred. Whether an excessive pressure was reached or whether the receiver had been locally weakened is not known. It is proper to call attention to the fact that the condition of the lower part of a receiver of this style, where water slowly but constantly accumulates and is occasionally drawn off, the surfaces being alternately wet and dry, is precisely that most promotive of rust. For the weakening of a receiver from this cause the makers cannot of course be held responsible. Receivers should be inspected and tested from time to time. Protective paint is often used outside, but it is really more needed inside.

COMPRESSED AIR IN COTTON INDUSTRIES

Compressed air as a power transmitter has always shown a remarkable faculty for finding new lines of employment for itself. When once installed for almost any purpose its use soon spreads to other convenient, economical and labor-saving applications. A little pamphlet recently issued by the Ingersoll-Rand Company, 11 Broadway, New York, *Some Economical Applications of Compressed Air in the Cotton Industries,* tells of some of these later adaptations.

One of the most important advantages of compressed air for this service is the fact that it is absolutely safe. There is no possibility of starting a fire with it; no danger of fiery "short circuits" or sparking motors; no possible damage to be done by a broken line; no danger to the mill operators. It is a clean power, and its discharge, anywhere, improves the quality of the atmosphere in that place. It does not require a specialist to look after it and keep it in trim. It has a happy faculty of "delivering the goods" with the minimum of care, attention and cost.

In cotton mills it has always been a problem to keep the machines, and particularly the looms, free from flying lint and dust. Collecting upon and interfering with the operation of the machinery, it has been necessary, in the larger mills, to shut down at intervals, and clean by hand, thus involving a waste of time, a loss of product, an increased percentage of "seconds" and the services of a cleaner. The modern method directs a jet of compressed air against the foul parts of the machine, blowing off the accumulated lint. Ring rails and spindle rails may be perfectly cleaned in this manner.

By this means the machinery in an entire room may be cleaned in a very few minutes without shutting down, and a better job will be done than is possible by hand; in fact, two men with an air jet can do the work of ten or twelve by the old slow method, besides saving the time and product formerly lost by the shutdown, and by the decreased amount of "seconds" produced. This little kink is saving time and money in some of the largest cotton mills in the country.

Compressed air can also be advantageously employed in cotton-seed oil mills for cleaning crushing rolls and separator plates. In an average sized mill it formerly took four men, working five hours each day, to clean these parts, the machine, of course, having to be shut down during the process. With compressed air, however, one man can do this work and do it more thoroughly.

Other applications of compressed air to these industries are almost too numerous to mention, it being possible to employ pneumatic motors, hoists, tools, displacement pumps and air-lift pumps to great advantage, the absolute safety of compressed air making it the ideal motive power for use in these plants.

The Cutler Hammer Company, of Milwaukee, announce the purchase of the Wirt Electric Company, of Philadelphia. The manufacture of the Wirt apparatus will be continued, and the current Wirt catalogue will apply for the present.

Baltimore has abandoned its municipal lighting plant because a private company offered to supply the same illumination at one-fourth the city's cost. And the two American Dreadnought contracts have just been awarded to private bidders because they underbid the navy yards, although the private bidders reckoned upon a profit and the navy yards estimated at cost.

WATER POWERS.

The following is from a lecture by Prof. John Harisberger to the class in Power Transmission, University of Washington (State):

Realization of profitable commercial and industrial conditions depends very largely on the possibility of obtaining cheap motive power, and the cheapest known power is that derived from natural waterfalls, which is energy coming nearest to being perpetual motion, having practical value, to be found on this globe.

In the transformation and transmission of this power into such shape that it can be applied to do useful work in localities where work to be done is desired, loss of power occurs. To keep this loss to a minimum is necessary for satisfactory commercial results. This is a problem for the engineer.

Taking for granted that a location has been found where water power can be developed and data as to preliminary work, regarding approximate fall and amount of water available, has been secured, the next step will be to check this data of preliminary work by taking accurate measurements of the flow of water in the stream for several months, desirably during the low-water season. If the elevation of the power site is 2000 feet or over, the supply of water for streams will be derived mostly from glaciers and melting snow, and the low-water season will be in the winter months; while with a power site nearer sea-level, the stream being fed by rain, springs, and melting snow in the foothills, the low-water season will be during the summer months. This is especially the case in the Northwest.

The watershed of the stream should be explored to ascertain the nature of the country drained, especially as to forests, and find out if the forests are private property or in the government reserve. Heavy forests on the watershed are of material value from a water-power standpoint, as they tend to regulate the rate of discharge of the stream. Their sponge-like property has the effect of retarding the flow of water to stream, and snow falling during the winter is protected from the sun by the trees, which is the cause of the gradual discharge of the stream instead of a spasmodic flow, as will be the case if the watershed be barren of trees. From this it is evident that it is desirable that forests in basins, at elevation below 3000 feet, drained by streams utilized for power purposes, be in the government reserve, for if they are private property it will only be a question of a short time when the trees will be cut down, thus destroying *one of the best and cheapest power storages we have.*

In the past it has been, and even now is, the practice to build the power-house of no greater capacity than the power of the stream at low-water flow, in which case at least seventy-five per cent. of the power available goes to waste by the water flowing to lower level without doing any useful work. Ideal conditions are seldom found as to watershed in its natural state, so that the flow of the stream is uniform the year around, so artificial means must be employed for the storage of the water that the entire flow off of the stream the year around can be utilized. If this can be done, a power-house of at least the capacity of average power of stream should be built.

Having obtained measurements giving hydrostatic head and flow of water, and knowing what the practical possibilities are for storage of water, the capacity of power-house that should be built can easily be determined by the following formula: Horse-power equals .1134 times cubic second feet times head times 71 per cent.

If an electric generator is employed, say for long-distance transmission, this gives the power at the switchboard, allowing for losses in pressure pipe, water wheels and generators, or about seventy-one per cent. of the power, which is about as good as can be obtained with apparatus available and average power sites. Many conditions must be considered when establishing location for intake and power-house. The possibility of back water interfering with the operation of the water wheels, which may be caused by floods occurring only about once in ten years should not be overlooked.

The shortest possible length of pressure pipe between intake and water wheels for a given head is desirable for good speed regulation with economical use of water. Satisfactory regulation is impossible when a long pipe line is used for a low water plant, and it is attempted to vary the velocity of the water in the pipe for speed regulation.

In high head plants, where the velocity of the water is kept constant in the pipe, governing being done by diverting part of the water from the runner of the water wheel, the question of length of pipe line will only be a matter of cost, and convenient locations for intake and power-house. The intake for pressure pipes should, if possible, be a storage basin of comparatively large area, so velocity of water will be very low, thus allowing any grit or sand to settle to the bottom. This basin should have a sluice gate, so sediment can be sluiced out occasionally without going down pressure pipes and through water wheels. Sand and grit are very detrimental to the life of water wheel runners, as well as the water wheel housing and pipe line, and every means should be employed to eliminate any sand from the water that is to come in contact with the water wheels. The higher the head the more important this is.

FOR A TRAINING COAL MINE

At the summer meeting of the Coal Mining Institute of America, held recently at Pittsburgh, President F. C. Keighley delivered an interesting and suggestive address from which we take the following:

There is not a vestige of a reason for the non-existence of such an institution as a training coal mine, any more so than a few years ago there was for the absence of a correspondence school of mines. The army has its West Point, the navy its Annapolis and training ships. The railroads send out their model air-brake and other cars in order that their men may be trained in those lines; even the United States Department of Agriculture sends out a car exhibiting the works of model farms to the farmers of every railroad community. The colleges of to-day have their machine, electric, carpenter, and other shops, foundries and laboratories. Manual training and model factories for facilitating it are to-day recognized as not only good things, but the proper and necessary fountain-heads for the issuance of a stream of skilled labor that is being clamored for the length and breadth of this great land; yet no place exists to-day where a young man who desires to make mining his life work can familiarize himself with systems, methods and practices, as he would be able to do in a model coal mine or training mine; call it what you will so that it may be given life. If the State of Pennsylvania is too poor to set the example, let some other State do it. If some other State should be first to take action, it would be to the eternal shame of the greatest coal producing State in the world, and of the wielder of a twenty-million dollar pen holder that is now writing messages of scorn for the taxpayers of the great State and the death warrants, as it were, of political thieves—and will continue to do so for some time to come.

The establishment of a model coal mine for the training of coal miners will save the great State of Pennsylvania so many millions of tons of black diamonds in the next decade that it can afford to forget the extravagance of flaunting before the world a twenty million dollar pen holder (the real value of which is not one-fourth that sum) as soon as the said pen holder has gotten through signing the death warrants of political jobbers. If this model mine cannot be tolerated as a business proposition, let it be one of charity—a place where the miner's orphaned boy can find a schooling and a home. There are many scores of men in this land that have each made money enough from coal lands and coal mining alone to enable them to not only donate or lease the coal land on a low royalty for such a purpose, but to provide such a mine without serious drain on their spending money or resources. Some man will do it some day, and at the same time do his nation so great a service that his name will rank high in the annals of the illustrious of this land.

THE OXY-ACETYLENE FLAME FOR STEEL CUTTING

The Davis Bournonville Acetylene Development Company of New York City, on June 13, under the western approach of the Williamsburg Bridge, gave a demonstration of steel cutting with an oxy-acetylene blowpipe flame, the operations being under the direction of the inventor of the torch and vice-president of the company, Eugene Bournonville.

The 6 in. side of a 6 x 4 x 5/8 in. angle was cut through in 1½ min. A plate 3/8 in. thick was cut into for a distance of 3 ft. 2 in. in 9 min. 36 sec. A 5 ft. built up I beam girder, consisting of a 3/8 in. plate for the web and four 6 x 4 x 5/8 in. angles at the edges, was practically cut through in 31 min. A 6 x 4 x 5/8 in. angle was completely severed in 2 min. 50 sec. In all of these tests there was used approximately 37 cu. ft. of oxygen and 18 cu. ft. of acetylene, at what pressure is not stated.

This process requires three tanks: one containing compressed acetylene, and the other two compressed oxygen, one of them at high pressure, in this case 900 lbs., although still higher would have been preferable. The low-pressure oxygen and the acetylene are first admitted to the blowpipe in proportions adjusted for proper combustion, and the flame is directed on the steel until the surface is well heated; then an additional jet of the high-pressure oxygen is passed through the torch and the "cutting" is really the direct burning of the steel in the path of the jet. The cut made is only about 1/8 in. wide, so that the loss of metal is not greater than in sawing or planing.

TROJAN NON-FREEZING POWDER

Trojan non-freezing powder, manufactured by the Independent Non-Freezing Powder Company, Allentown, Pa., is an explosive compound said to contain no nitro-glycerine or picric acid. It is claimed that the powder will not freeze and that on explosion no injurious fumes are given off. The powder is reported to have an explosive force equal to that of nitro-glycerine dynamite, and that in two years of practical rock-drilling tests the powder has met all requirements. It is put up in cartridge form and can be detonated by ordinary methods. One of the advantages claimed for the new explosive is that the absence of poisonous gases permits the workmen to return to their work immediately after blasting.

The Baldwin Locomotive Works has recently completed an order for twenty locomotives for a French railroad. These were all built to French drawings and specifications, with, of course, French or metric measures throughout. It would have been a strange thing if intelligent American workmen had not been able to work with perfect ease and accustomed accuracy to those measures as well as to any others. Of course there were special jigs, templets, gages, etc., required, but on the whole we may assume that the contract was remunerative or it would not have been undertaken. There may be in it a promise or a possibility of more contracts to come. If other manufacturers in other lines can get, at prices assuring profit, machinery to build to metric measures undoubtedly they will be glad enough to do it. Absolutely no legislation is required for it any more than law tinkering is required to enable German manufacturers to produce, as they do, building blocks to inch dimensions for American children.

THE WHISTLING BUOY

The whistler is the monster of the buoy family, sometimes reaching a height of over 36 feet and weighing three tons or more. Naturally, such enormous pieces of mechanism have to be handled very carefully in the sea, and the placing and removing of these buoys is a work of decided interest and some hazard, all the greater because a whistling buoy is never placed except where the water has some swell most of the time.

The buoy has a long tube projecting downward, a whistle on top and an air intake provided with a valve. When the buoy is placed, the tube fills with water. When a wave raises the buoy the water recedes in the tube and air comes into the bulb through the intake. When the wave passes and the buoy drops again, water is forced up the tube. The valve of the air intake pipe closes of its own accord from inside pressure, and the air compressed by the weight of the water thrust upward escapes through the whistle, making a sound of the most indescribable sadness and melancholy—weird and mournful in the last degree. So marked is this characteristic of the buoy that the Lighthouse Board has to weigh well the advisability of placing one of these buoys within earshot of near-by dwellings, because of the emphatic protests of the owners of property against the depressing influence of the sound.—*Yachting*.

AIR BRAKE AIR CONSUMPTION OF PASSENGER AND FREIGHT LOCOMOTIVES

Railway and Locomotive Engineering thus discusses the relative compressed air needs of passenger and of freight locomotives:

It might seem at first thought that the passenger locomotive could get along comfortably with a smaller pump than is required for the freight; a little reflection—and calculation—will show that a passenger train of ten moderately heavy cars requires as much air to operate its brakes as is required by a freight train of nearly four times the number.

The capacity of a 16 by 33 inch auxiliary reservoir is about 3,900 cubic inches, and that of an 8-inch freight auxiliary about 1,600 cubic inches, so that the passenger auxiliary has nearly three times the capacity of the freight.

To charge one of the 16 by 33 inch reservoirs to 110 pounds pressure requires about 29,250 cubic inches of free air, and to charge ten of them to this pressure requires 292,500 cubic inches.

To charge an 8-inch freight auxiliary to 70 pounds pressure requires approximately 8,000 cubic inches of free air, and from this it may be seen that the quantity of air required to charge the ten auxiliaries to 110 pounds pressure would be sufficient to charge 36 8-inch freight auxiliaries to 70 pounds pressure.

The capacity of a 16-inch by 42-inch reservoir, such as is used with the 16-inch brake cylinder, is about one-third greater than that used with the 14-inch brake cylinder. Hence, if the cars were equipped with 16-inch instead of 14-inch brake cylinders the air required to charge their reservoirs to 110 pounds pressure would be sufficient to charge forty-eight 8-inch auxiliaries to 70 pounds.

From the above it may be seen that the big pump on long passenger trains does not have to remain idle much of the time if stops are numerous.

In addition to supplying the brake system with air it must also take care of the air signal and the water raising systems, which make a slight additional demand not required of the freight engine's pump.

WORKING CONDITIONS FOR COAL CUTTERS

The following information concerning the conditions which make the employment of air-operated coal cutters profitable or otherwise is abstracted from a voluminous report to a British parliamentary committee:

"The mechanical cutting of coal has been in operation at collieries for a long time, being first introduced in the latter half of the last century, but it did not pass out of the experimental stage for many years.

"That the use of mechanical cutters has spread, and is extending in the coal mines of the United Kingdom, is demonstrated by the fact that, whereas in 1900 an output of 3,321,012 tons was obtained by the use of 311 machines, in 1905, the most recent year for which figures are available, the output had increased to 8,102,197 tons, produced by 946 machines.

"In the United States the use of mechanical coal cutters is much more advanced than in Great Britain; for instance, in 1905 there were no less than 9,184 machines working, producing 92,318,261 tons, and, comparing the amount of coal produced in that country with the British output, it might be urged that the great increase in the former is due to the special adaptability of the seams to the use of coal cutters, but it is doubtful whether this alone will account for the greatly extended adoption of machine cutting in America.

"It may be mentioned that the great majority of the machines used in the collieries of the United States are those designed for the board and pillar system of working, whereas in Great Britain machines suited to the longwall method of working coal are most generally used, which method of mining is better adapted to the advantageous use of machinery for undercutting (holing or kirving) coal. This would seem to point to the fact that the advantage of machine mining in Britain is relatively greater, for the machine-worked seams in America are thick, and thick seams, most of the witnesses informed us, can be more profitably worked by manual labor. But thickness of seam is not the only governing factor in the economical application of mechanical coal cutters. The use of coal cutters is conditioned by:

(*a*) The character of the roof of the seam.
(*b*) The thickness of the seam.
(*c*) The nature of the coal.
(*d*) The inclination of the seam.
(*e*) The character of the floor of the seam.
(*f*) Geological disturbances.

"For example:

"(*a*) Where the roof is of such a character as to render close timbering necessary, and there is not sufficient room for the machine to traverse the face, or it is unsafe for it to do so, cutting by machinery is impossible.

"(*b*) A thin seam, by which is meant a seam of 3 feet or under, is, presuming the roof is good, and the coal sufficiently hard to stand for holing, more profitably under-cut by machinery than by hand, as the thinner the seam the greater the hewing price paid to the miners, also less small coal is made in holing by machine than by hand holing. On the other hand, in excessively thick seams, such as the thick coal of South Staffordshire and part of Warwickshire, it is impracticable to utilize coal-cutting machinery; the cut would not remain open, and the noise of the machine would introduce an element of danger, when at certain periods of mining operations quiet, as pointed out by Mr. Hughes, is very necessary. But, as shown by the report of the committee of the North of England Institute of Mining Engineers on Mechanical Coal-Cutting, there are numerous instances of machines at work with undoubted success in seams up to 6 feet in thickness.

"(*c*) Where the coal is excessively hard to hole (under-cut) and there are no other adverse conditions, it might be less costly to perform this work by mechanical cutters than by hand. But where a seam is of such a character that it will not stand for under-cutting, owing either to the softness of the coal or its liability to breaking away (South Yorkshire), or owing to the existence of joints in the coal (slips or backs), as in the case of the steam coal collieries of South Wales, or when the coal settles down behind the cutting machines and can not be kept up, mechanical coal cutting can not be resorted to.

"(*d*) When seams are highly inclined longwall coal-cutting machines can not be used (Swansea district and part of North Staffordshire).

"(*e*) When the floor of the seam is a bed of fireclay, it is frequently profitable to hole in it by machines. An evenly graded floor is a desideratum.

"(*f*) Successful mechanical coal-cutting is nearly always impossible in seams much intersected by faults or dykes, especially in collieries worked on the longwall system."

A FREE LABOR EXCHANGE FOR ITALIANS

During the fiscal year ending June 30, 1906, the number of Italian immigrants entering the United States was 273,100, a number greater than of any other nation. The number for the present year is much higher than this. The larger percentage of these are uneducated, cannot speak English and are so poor that they must have immediate employment. The so-called agents who have pretended to assist them have charged exorbitant fees, both to the laborers and to the employers.

Some American gentlemen last year decided to form an organization for the purpose of creating a free labor exchange, to act as an intermediary between those seeking employment and those who would employ them. These gentlemen are: Mr. Augustus Healy of New York; Mr. Giovanni P. Morosini, banker, of New York; the late Mr. Joseph Ratti, of

Bloomsburg, Pa.; Mr. Joseph Tuoti, and Mr. C. A. Aimone.

The office was opened in April, 1906, under the name of the "Labor Information Office for Italians," at its present address, No. 59 Lafayette St., New York City; and, although it threatened some rather powerful interests, from the date of its opening up to June, 1907, it had secured employment for 7,194 persons—of which number 2,493 were employed in the last five months. Also during this last period 319 employers made application for help, and 5,532 Italians were advised as to the conditions of work, wages, etc.

The office has still another aim, which is of national interest—the distribution of newcomers throughout the United States. It is well known that most of the Italians coming to this country settle in the large cities of the East; while they would be of much better use to their new fatherland if they would go to the Western and Southern agricultural regions.

The Italian laborer has become of vast importance in the industries with which the rock drill and the air compressor have to do, and employers in these and affiliated lines will do well to open communication with this exchange. G. di Palma-Castigliane, Manager, may be found or addressed at 59 Lafayette (formerly Elm) St., New York City.

A printed form has been prepared for employers asking the following questions:

Name and address? Kind of work and where? Permanent or temporary, and, if the latter, for how long? Number of men wanted? Hours of work? Rate of wages offered? Pay-days? Will transportation expenses be refunded? Is knowledge of English requisite? Do you provide medical attendance and at what rate? How long is this application good? Is there any strike or labor trouble? Correspondence might generally be expedited by answering these questions in the first communication.

NOTES

The address of the Fornham Sand Blast Company is 41 Park Row, New York City.

"Advertising in Reference Books" was the subject discussed at the May meeting of the Technical Publicity Association. At the first fall meeting of the Association in September the topic will be "The Mailing List."

The Automatic Air Compressor Company of Bridgeport, Conn., has filed a certificate of incorporation, the incorporators being John Rogers, E. F. Coleman and James A. Pease. The authorized capital is $50,000.

The exhibit of the Allis-Chalmers Company, Milwaukee, at the Jamestown Exposition, includes a portable air compressor built on the principle of the Christensen compressor. It is built for capacities of 11, 16, 20 and 50 cubic feet, and is furnished mounted on an ordinary four-wheel platform truck. It is adapted to use in small shops, where the need for compressed air does not warrant a large stationary compressor.

The William Tod Company, Youngstown, Ohio, is building for the new plant of the Indiana Steel Company, Gary, Ind., four horizontal cross compound steam blowing engines of large capacity, which will form an important part of the blast furnace equipment. These engines are 44 and 84 x 72 in., with air cylinders 90 x 72 in. Each engine has a capacity of 50,000 cu. ft. of free air per minute.

The Piqua Blower Company of Piqua, Ohio is being incorporated under the laws of Ohio, with a capital of $50,000. This corporation will take over the interests of the Piqua Foundry and Machine Company of Piqua, Ohio, and will make a specialty of the manufacture of positive blowers and gas exhausters as developed by the latter company in the past two years. As the machinery of the latter firm has met with great success, it is necessary to effect this reorganization in order to take care of the large volume of business offered.

The Sprague Electric Company of New York City has opened a district office in the Hennen Building, New Orleans, which has been necessitated by the constantly increasing business in its various products in the southern territory. This office is under the management of Mr. F. V. L. Smith, lately Chief Inspector of the Louisiana Bureau of Fire Prevention, and will cover the territory included in the States of South Carolina, Florida, Alabama, Georgia, Tennessee, Mississippi, Louisiana, Arkansas, Texas, Oklahoma, and Indian Territory.

The Billings & Spencer Company, Hartford, Conn., has recently occupied its new machine shop, one of the finest in New England. The building is 55 x 250 ft. with monitor roof over a crane bay, and broad galleries for the lighter machine work. A 20-ton Niles electric traveling crane serves the central bay, with a number of jib cranes for the heavy individual machine tools. Spacious elevators serve the galleries on each side. The water supply for the entire plant is supplied by Ingersoll-Rand compressors and the Air Lift.

The Independent Pneumatic Tool Company, Chicago, writes as follows: Our business since the first of the year has shown a remarkable increase over the corresponding period of last year. Although we have greatly enlarged our plant at Aurora, Ill., increasing our output 50 per cent., we are unable to meet the demand for our Thor Pneumatic Tools. Our plant is in full operation night and day, and we have sufficient orders to keep running for several months. Before the end of the year we expect to double our facilities. We are receiving a large number of orders for export.

In the erection of the 32-story building of the City Investing Company now in progress at Broadway and Cortlandt streets, New York, the ¾" and ⅞" rivets in the connections are driven by 16 four-man gangs, with Cleveland pneumatic hammers operated by pressure from two Clayton duplex air compressors lolated in the basement. These deliver to separate receivers, but a single 2½ inch vertical pipe from both receivers is run up near the center of the building with a 2 inch horizontal branch at each floor which runs to both ends of the building with 16 outlets for the air hose to the hammers.

In the erection of the Trust Company of America building, 41 Wall Street, the field rivets were driven at the rate of about 300 per day by each of eleven 4-men gangs, using Chicago pneumatic hammers operated by an Ingersoll-Rand steam driven compressor and a Chicago electrically driven compressor, each of which was of sufficient capacity for the entire work and both being provided to guard against delay in case of accident.

An interesting work now in progress is the Minidoka irrigation project of the U. S. Reclamation Service, in the south central part of Idaho. It embraces among other things a dam across the Snake River, a controlling works, and the headworks for a main irrigation canal at one end of this dam, and a long spillway and the headworks for a second main canal at the other end of the dam. The excavation of the diversion channel has been largely in lava rock, Ingersoll-Sergeant drills being used for the blast holes. Air for the drills was furnished by an Ingersoll-Sergeant compressor installed about 800 feet from the controlling works. The air was used also for operating the concrete mixer, the hoisting engines for the derricks used in connection with the cableways and for a pump at the river which supplied a system of water distribution extending to all parts of the work and to the construction camp.

RECENT U. S. PATENTS

MAY 21.

854,009. AUTOMATIC TIDAL AIR-COMPRESSOR. William O. Webber, Boston, Mass. Filed Sept. 17, 1906. Serial No. 334,992.

854,371. AIR-COMPRESSOR COMBINED WITH AN EXPLOSIVE-MOTOR. Andre Michelin, Paris, France. Filed Dec. 14, 1906. Serial No. 347,806.

854,694. PORTABLE PNEUMATIC TOOL. Charles H. Haeseler, New York, N. Y., and Albert H. Taylor, Easton, Pa., assignors to Ingersoll-Rand Company, a Corporation of New Jersey. Filed Dec. 8, 1906. Serial No. 346,969.

MAY 28.

855,050. COMPRESSOR. Charles W. Dietrich, Chicago, Ill. Filed Dec. 15, 1906. Serial No. 348,087.

855,433. PNEUMATIC DUST-REMOVER. Miles E. Freeman, Bradford, Pa., assignor of one-half to James J. Freeman, Bradford, Pa. Filed Aug. 24, 1905. Serial No. 275,586.

JUNE 4.

855,518. APPARATUS FOR ELEVATING WATER BY MEANS OF COMPRESSED AIR. Andrew M. Lockett, New Orleans, La. Filed June 25, 1906. Serial No. 323,253.

855,697. AIR-COMPRESSOR. Louis B. Cousans, Lincoln, England. Filed Feb. 28, 1905. Serial No. 247,771.

856,083. PNEUMATIC DRILL. Peter H. Murphy, St. Louis, Mo. Filed June 16, 1905. Serial No. 265,506.

856,109. PNEUMATIC TRANSMISSION SYSTEM. Joseph J. Stoetzel, Chicago, Ill. Filed March 14, 1906. Serial No. 305,960.

855,976. DROP-HAMMER. Carl Prott, Hagen, Germany. Filed June 9, 1906. Serial No. 321,020.

856,194. PNEUMATIC-TOOL HANDLE. Frederick S. Graham, Philadelphia, Pa., assignor of one-third to Ralph M. Seaman and one-third to Charles A. Struntz. Filed Nov. 9, 1906. Serial No. 342,713.

856,145. HAND-HOLE FOR PNEUMATIC-TUBE SYSTEMS. Walter V. Hart, Maywood, and Frank J. Novak, Chicago, Ill. Filed Oct. 25, 1906. Serial No. 340,504.

JUNE 11.

856,510. PNEUMATIC VEHICLE-SPRING. George W. Bell, Liverpool, England. Filed June 22, 1906. Serial No. 322,810.

856,636. PUMPING MACHINERY. Charles L. Heisler, St. Marys, Ohio. Filed Oct. 5, 1906. Serial No. 337,650.

856,651. PNEUMATIC DRILL. Peter H. Murphy, St. Louis, Mo. Filed Dec. 11, 1905. Serial No. 291,248.

856,706. PNEUMATIC TOOL. William H. Keller, Philadelphia, Pa. Filed Jan. 9, 1906. Serial No. 295,230.

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COMPRESSED AIR FOR STEAM HAMMERS

By Frank Richards.

It is proposed here to consider the economy and expediency of employing compressed air for driving steam hammers and to indicate the conditions under which it is profitable and advisable. If it shall appear to be an *ex parte* plea for compressed air for this purpose it is still believed that the position taken is in strict accord with fact and experience.

The recent suggestion of an engineer of high repute and of large engineering experience that steam hammers "are not successfully operated by compressed air" is, according to my information, as far as possible from the fact. Not only are many steam hammers so operated, but they are always operated with satisfaction if not always with computable economy, and when once air is employed for the purpose its use is rarely abandoned.

It has come in my way to know something of the manufacture of rock drills. These drills are built to be operated some by compressed air and some by steam, and every drill is tested at the factory before it is sent out. This testing operation is much more thorough and exacting than the term suggests. Each drill is run for a considerable time under different conditions of stroke, pressure, etc., until it is found to work correctly under all normal requirements. It happens that all steam drills are tested first of all with air and after that with steam. The invariable experience is that the drill is more lively and operates more satisfactorily in all respects with the air than with steam. After the drill is found to run all right with air it still requires more or less of coaxing or breaking in before it works equally well with steam, the latter being always the more difficult proposition.

The rock drill is only a smaller steam hammer, and the experience with the drill is closely typical of general experience with the hammer. It must be confessed that the use of steam in the steam hammer is never without a number of objectionable accompaniments. We speak now of the hammer as situated not far from the boiler and as supplied with comparatively dry, live steam. The piston or tup is a solid mass, its weight being largely depended upon to give force to the blow, and the cylinder also is much heavier than that of a stationary engine of the same diameter, and when the steam is turned on its first work is to heat up all this weight of metal, thus involving the condensation of a large quantity of steam and the flooding of everything with water. No matter how perfect may be the arrangements for taking care of the water, it still works out of the stuffing boxes, drops around where it is not wanted and is the familiar and constant nuisance of the steam operated hammer. The hammer also is never operated continuously, so that this warming-up and steam condensing operation is repeated more or less every time the hammer is started. The cost of steam wasted by condensation is quite an appreciable addition to that of the steam employed for the working. There are expansion troubles also connected with the use of steam, the parts not heating up and expanding equally, so that the warming-up process every time the hammer is operated also requires the playing of the hammer up and down, the working of the valves to have them free, etc., and besides the steam consumed considerable time is required. This does not necessarily imply any delay of the work, as the hammer may be got ready beforehand, but it takes the time of a man who might be doing something else.

Steam thus charges continually for waiting in readiness as well as for the actual work it does, while compressed air costs nothing except for work actually done, and this it is always and instantly ready for. The hammer the first thing in the morning is readier to go with full force the instant the air is turned on than it is with steam after fifteen minutes of warming and limbering up, and the same warming up is required more or less every time the hammer is operated.

Another important point is the lubrication of the hammer. With air the oil remains on all the working surfaces the same as with machinery which is all exposed, while with steam the oil disappears almost immediately and lubrication must be almost continuous and requires constant watching. This reliability and constancy of lubrication in the one case and the precarious uncertainty of it in the other is especially brought out in drill testing.

In considering this matter it will appear all the way through that it is not to be settled by merely comparing the costs at the boiler or the power-house. The constant readiness, the handiness and liveliness of operation, the saving of the time of the workers at the hammer, outweigh in each individual case many pounds of coal.

When the hammer is operated at a distance from the source of power, the advantage in the use of the air is more pronounced. A steam pipe is of course losing heat and condensing steam all the way along, and the steam is wet and heavy when it gets to the hammer, while there is practically no loss in the transmission of the air, and absolutely no difference in its working readiness at the hammer.

There was recently a specific case up for consideration in which if steam was used it would be necessary to pipe it 1800 feet. The loss by steam transmission even with costly heat insulation would be quite large for this distance. In the case of the air there might be a fall of pressure of one or two pounds; this loss is easily computable when the conditions are specified, and the loss of pressure would be almost entirely compensated for by the corresponding increase of volume delivered. The loss by leakage, assuming the piping to be properly laid, would be so small as to be entirely negligible.

We give here what data we have immediately available as to the air required for operating a steam hammer. We have information of many plants where steam hammers are driven by compressed air, but in every case some of the air is used for other purposes, so that it is not possible to get the actual air consumption in any given case, and this would be difficult of ascertainment for purposes of comparison in any case, on account of the intermittent use of the hammers and the difference in the total time of employment in each case as compared with any other.

As a starting item we may note the statement of the Niles-Bement-Pond Company that the largest amount of free air required for continuous running of a steam hammer is 26 cubic feet per minute compressed to 90 pounds for each nominal 100 pounds weight of hammer. For hammers used in the ordinary way, or with the average of stoppages, the consumption may be placed at 13 cubic feet per minute.

The cost of compressing to 90 pounds, two stage compression, is about .163 horse-power per cubic foot free air per minute, or for 26 cubic feet, as above, 4.24 horse-power and for 13 cubic feet 2.12 horse-power per 100 pounds of hammer. To operate with steam under conditions similar to this last instance the same authority says that 1 horse-power of boiler capacity should be allowed for each 100 pounds of hammer, the boiler located within a reasonable distance.

The Star Drilling Company, Akron, Ohio, have three hammers with an aggregate weight of 4,200 pounds. At the lowest figure given above these would require $42 \times 13 = 546$ cubic feet, and the horse-power required would be $42 \times 2.12 = 89$. These hammers take care of six fires, and sometimes eight, and are supplied by two compressors whose nominal (greater than actual) free air capacity is 336 and 296 cubic feet respectively, one-quarter of the air being used for other purposes. We have then 336 + 296 cubic feet = 632 — 177 (one-fourth) = 455 cubic feet, or 90 cubic feet less than the lowest called for by the Niles-Bement-Pond *rule*. The compressors are driven by gas engines using natural gas; the power cost chargeable to the hammers is $52.28 per month.

Of the advantage in the use of air in this plant it is noted as follows:

"The hammers do more work than with steam. There is no trouble in starting to work out the water. Hammers work more lively and freely. No hot water dripping and no additional heat. The air pressure is constant, while with steam there are serious fluctuations and the blows of the hammers are uneven. No steam is used in this plant and the installation is considered more economical and satisfactory with the air."

The main blacksmith shop at the Phillipsburg, N. J., shops of the Ingersoll-Rand Company, the location and arrangement of which, for convenience, efficiency and economy of operation, were given careful consideration, is very near the boiler plant, and the ten or twelve large hammers there are all operated by steam. There is here a Stirling water tube boiler mounted in connection with the reverberatory furnaces to utilize the waste heat, this boiler being connected by an equalizing pipe with the main steam supply pipe of the works. When at times more steam is here generated than is being used by the hammers it goes into the main supply, while when, for instance, most of the hammers are working at once the flow is the other way. Here as elsewhere the difficulty of ascertaining the actual consumption is apparent, but the arrangement in every other respect has been satisfactory.

In the oil tempering and tool dressing shop of the same works, located a little farther from the boilers, there is a hammer of medium size driven by air. This also is satisfactory, and the best arrangement under the conditions.

The air and steam consumption of steam hammers where any records are obtainable vary widely, as might be expected.

The West Manufacturing Company, Buffalo, N. Y., tested a hammer 9" by 15" by actually running it continuously at 150 blows per minute, the air at 80 pounds gauge, and using it at the rate of 230 cubic feet per minute as measured by the piston displacement of the compressor. As a matter of fact, in actual, every-day service, the compressor, running at the capacity above recorded, supplies this hammer, also a 7" by 12" hammer, five large air hoists, twelve small hoists, and a number of live air jets for blowing off scale, etc., and besides that the compressor "unloader," which stops the air compression, is in operation a considerable portion of the time.

The Buffalo Pitts Co. have a two-stage compressor with a nominal capacity of 350 cubic free feet air per minute which ran a 700 pound hammer, 10" by 22", at 150 blows per minute, maintaining 100 pounds pressure. This compressor in actual shop work runs this hammer, a smaller one, an air riveter and a number of smaller pneumatic tools.

The Shiffler Bridge Company, Homestead, Pa., have a two-stage, power-driven compressor with a maximum capacity of about 500 cubic feet of free air per minute which drives two steam hammers, the air being used also for a great number of other purposes, the blacksmith shop with the hammers being a long distance away.

At the Painted Post shops of the Ingersoll-Rand Company there is a 500-pound hammer operated by compressed air, and a 1,000-pound hammer, no longer in use, was so driven. Mr. F. W. Parsons, Superintendent of the Rand shops, writes as follows:

"If the hammers were kept pretty busy doubtless steam would be the most economical of fuel, but, as they are often operated with long waits between, you get with the steam a good deal of condensation and this causes lots of bother when starting up, the iron cooling rapidly while waiting. Unless the packings are very well kept up water of condensation drips on the anvil and forging, which is annoying and sometimes dangerous. Of course with air there is none of this trouble, there is no loss when the hammer is not in operation, and with an equal pressure more work will be done using air than if steam were used. With long and exposed pipes, as are often used for steam to hammers, and especially where the hammers are not kept busy, it is more economical and certainly otherwise more satisfactory to use air."

The Eliott Frog & Switch Company, East St. Louis, Ill., are operating a hammer with compressed air because it is so far from the boilers, and they have an air supply for general purposes. They find that on account of the condensation of steam, etc., they operate the hammer to better advantage by the use of the air.

There are many railroad shops using air for steam hammers, but we have no available specific information concerning them. We never hear of the air being discarded after being once employed for this purpose, except for other reasons than those immediately pertinent to the hammer service.

The intermittent use of hammers makes a large air receiver capacity desirable, and the reheating of the air is, of course, always promotive of economy. The Trimont Manufacturing Company, Boston, have a 2,000-pound hammer which is supplied with air at 100 pounds by an electric driven, two-stage air compressor of 358 cubic feet capacity, the unloader in this case being in operation about a quarter of the time. There are three air receivers 54 inches diameter by 12 feet long, and the air is reheated by twenty-four 1-inch pipes 2 feet 6 inches long, connected to headers and placed in the hood over the forge fires. The reheating in this case is highly effective, as the exhaust from the hammer is hot to the hand and has considerable unused pressure. The bills for current for this compressor and isolated hammer amount to about $140 per month.

It happens that this Company has also a large steam-operated plant which shows the advantage of aggregation. There are one 5,000-pound hammer, six of 2,000 pounds each and two of 1,000 pounds. The large hammer is used so infrequently that it is assumed to require only the same steam as a 2,000-pound hammer, the aggregate being thus equal to eight 2,000-pound hammers. These are supplied with steam by a 175 horse-power boiler. The coal, labor, etc., are estimated to amount to $35 per horse-power year, the total cost for the year being 175×35 = $6,125 or 6125÷8 = $765 for each hammer, or 765 ÷ 12 = $63 per month.

To use air instead of steam no change is required at the hammer. Pipe up as with steam and it is ready at once. Every one likes the air; it keeps the room cooler for the men; there is no water threatening to scald, spattering on the hot forging. Part of the exhaust may be used for blowing the scale off, giving cleaner and smoother work. Only a small amount of air is required for this, as the air is dry and clean. The wear on the hammer itself is invariably in favor of the air, the wet washing out the oil, deranging the packing and causing leakage of piston, valves and stuffing boxes. With air the surfaces polish like glass, remain constantly more or less greasy with little or no wear, and the action is lively and prompt at all times.

A STUDY OF WIND PRESSURE ON A MOVING TRAIN

The following suggestive and interesting discussion is contributed to *Engineering*, London, by W. E. Wilson. We present it in a somewhat abridged form:

When there is a strong side wind blowing on express trains it is necessary to burn considerably more coal in order to keep up their speed. The usual explanation is the extra friction produced on the flanges of the wheels by the wind-pressure forcing the train over on the lee-rail. It seems to me that there is a much more potent cause for this retardation, and one which I think has escaped observation. It is the force necessary to accelerate the air which is blowing between each coach and the next. Let us take a typical case where the velocity of the train is 50 miles an hour, and the velocity of the wind 50 miles an hour at right angles to the rails.

Then—

Velocity of train = 4400 feet per minute.

Velocity of wind = 4400 feet per minute.

Let

Area of railway coach end = 8 ft. × 8 ft.

Distance between coaches = 4 ft.

∴ Volume of air passing between each coach and the next per minute = 140,800 cubic feet.

Mass of air passing between each pair of coaches per minute = 140,800 × 0.08 = 11,264 pounds.

$$\therefore \text{Force} = \frac{11.264}{32} \times \frac{4400}{60\times 60}.$$

$$\therefore \text{Work} = \frac{11.264}{32} \times \frac{44}{36} \times 4400 = 1{,}892{,}704.$$

$$\therefore \text{H.-P.} = \frac{1{,}892{,}704}{33{,}000} = 57.3.$$

Therefore, in the above typical case the engine would have to develop about 57 horse-power more for each space between the coaches of the train than when the train was run in a calm. Even with quite a moderate wind velocity we could easily get a retardation, due to, say, 10 horse-power per coach, which in a long express train might amount to a total of 20 per cent. of the horse-power of the engine.

It might at first be thought that the theoretical amount of air would not flow between the coaches, but would probably be broken up in eddies. I find by experiment that this is not the case, but that, on the contrary, considerably more air passes between the coaches than we have assumed. Mr. C. Seymour, C. E. of the Midland Great Western Railway of Ireland, has kindly measured for me with an anemometer the wind velocity across the rails and the velocity between the coaches. His figures were:

Observation No. 1, near Longford—Velocity of wind, 350 meters per minute (13 miles an hour); velocity of wind between coaches, 700 meters per minute (26 miles an hour); velocity of train, about 30 miles per hour.

Observation No. 2, near Edgeworthstown—Velocity of wind, 500 meters per minute (18.6 miles an hour); velocity between coaches, 790 meters per minute (29 miles an hour); velocity of train, about 40 miles per hour. The cause of this increase in the wind velocity between the coaches when the train is in motion is, I think, evidently due to the momentum of the mass of air being destroyed on impact against the sides of the coaches, and this must cause a considerable rise of air pressure along the windward side of the train; also, the air which has just passed the front of the train must have its momentum reduced by the advance of the train, which would cause a reduction of pressure along the lee side of the train; this difference of pressure between the windward and lee side would certainly cause an acceleration of the wind between the coaches. This difference of pressure on the sides of the train must be a function of the train's velocity as well as the wind's velocity. If the train is at rest, the pressure is entirely due to the change in direction of the flow of air round the train, and this soon becomes a steady flow; but when the train is in motion it is continuously destroying momentum of fresh air as it advances, and this appears as an increase in the difference of pressure on the side of the train. The same effect can be seen in the efficiency of bilge keels to stop rolling of ships. When the ship is in motion ahead, the bilge keel is always entering the water which is at rest with the ship, and in order to roll she must accelerate this dead water up to the velocity of roll; but when the ship comes to rest, the only available energy she has is the friction of the keels through the water, which is evidently much less than in the former case, when in motion.

MODERN DEVELOPMENTS IN ENGINEERING RESPONSIBILITY

The following we take from the Presidential Address, by Charles B. Dudley, chemist of the Pennsylvania Railroad, at the Atlantic City meeting of the American Society for Testing Materials:

"It is plain that in using materials in those constructions which involve safety in the railroad sense, or risk of human life in the public sense, there is a question of responsibility involved. If rails are defective and break; if an accident with loss of life results from the use of poor material in car construction; if a bridge falls and produces a disaster due to inferior materials, or a building collapses from the same cause, it is clear that some one should be held responsible. And since there are but two parties involved in the materials—*viz.*, those who make them and those who accept and use them—it is difficult to see how one or the other of them is going to escape the responsibility. Our problem is, Which of the two in equity should be held responsible? It is, perhaps, hardly wise at this time to attempt a definite answer. Much might be said on both sides, and probably no two persons, certainly neither of the two parties most interested, would give the same answer. But there is a phase of the case which we would like to present.

"It is well known that in the earlier structural work, when safety was involved, there was no testing worthy the name, and materials were bought and used on the reputation of the maker. Fortunately, the constructions in most cases had a high factor of safety. When disaster did come, if it was due to defective materials, it was explained that the materials used were from those of the highest reputation in the business, and that no one could really be held responsible.

"At the present time conditions have changed. The knowledge of the properties of materials of construction has increased, methods of testing and testing appliances have grown up in delightful profusion, and it is today entirely possible, we feel safe in saying, for an engineer to be reasonably sure that defective material does not go into his structures. We waive here the discussion of commercial considerations as affecting the use of materials. If it is shown that these have led to the use of defective materials, the moral responsibility for loss of life must certainly go to the one who has allowed commercial considerations to have such undue weight, be he the maker of the material or the one high in authority who has allowed it to be used. But the point we want to make is, in view of present knowledge and present means and appliances for testing, are engineers or their principals any longer entitled to offer as an excuse for defective materials that they were bought from the best makers? Can they equitably do so? Can they legally do so? Is not the time near at hand when engineers and their principals will be compelled, if not legally, then by force of public opinion, to acquire by the establishment of laboratories and means of testing, by the making and enforcement of specifications, such knowledge in regard to the materials they are putting into structures as will give the public greater security than it now has against disaster?"

PNEUMATIC INK DISTRIBUTION

The new building of the Baltimore *Sun*, which is electrically operated throughout, has in its equipment two 30 horse-power electrically driven air compressors which maintain a service pressure of 80 pounds. The air is used for pneumatic tube delivery, serving ten stations, for sidewalk freight elevator, etc., but its most important service is for a pneumatic ink distribution, which is one of the notable appliances of the press room. The distributor consists of a reservoir which holds 3,000 pounds of ink and is readily filled by gravity from a platform above it. From the reservoir tubing extends to a conduit the surface of which is adjacent to the ink cylinder of each press. The conduit has a series of openings through which the ink is sprayed by air pressure upon the surface of the ink cylinder. The distribution of the ink is regulated by the speed of the press and the flow shut off when the press ceases its motion. No attendant is required for "inking," as it is done entirely automatically.

MINE AND TUNNEL VENTILATION

The rate of air flow under a given pressure difference is proportional to the density of specific gravity of the fluid. A pressure of one ounce per square inch will create in the case of water only a sluggish stream, while in the case of air, which is more than a thousand times lighter, the velocity will be a mile a minute. For all purposes of ventilation this pressure and velocity are seldom exceeded and efficiency of movement is to be sought in their reduction to the minimum consistent with the cost of the conduit of greater area.

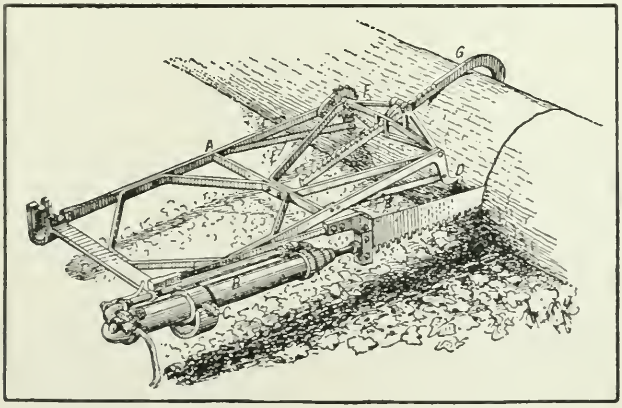
Ventilation may be readily defined as the replacing of foul air by pure air. The air may be contaminated within by exhalation from the lungs, by dust, by smoke or foul odors, and the system may be designed to withdraw the foul air and force in the pure air—still the result sought is the same. For the plenum or pressure system it may however be exclusively claimed that the air may be made the conveyor of heat and that absolute control may be had over the quality and quantity. The transport of air under such high pressures as obtain in compressor practice must, as a rule, be considered within the field of power transmission rather than of ventilation.

The operation of any ventilating system manifestly depends upon the creation of a pressure difference, which may be produced either by the somewhat crude methods of heating and thereby reducing the density of the air within a vertical flue or by various mechanical means. The former method approaches efficiency only where, as in the case of a chimney, the heat would otherwise be wasted. But even here, since the advent of mechanical draft, simplicity hardly offsets expense where the opportunity is proveded for utilizing the waste heat, as may be done by an economizer. For the movement of air upon a larger scale under moderate pressure the fan blower is the embodiment of efficiency and simplicity. Although the disc and propeller types of fans have a field of usefulness when operated under very low resistance, the centrifugal type of fan has been universally adopted for all general purposes of ventilation, particularly in connection with heating systems.

After the completion of the Gallitzin tunnel in the Pennsylvania railroad it was found that great difficulty was experienced on account of the smoke and gases discharged by locomotives.

These caused the atmosphere to become so bad that the trainmen sometimes became unconscious and it was necessary to provide relief. This was done by constructing at the east end a ventilating apparatus consisting of a sheet iron hood about 50 feet long, enclosing one track and having an inner surface coincident with the soffit of the tunnel arch and walls. The outer surface so converged from the outer end of the hood to the portal of the tunnel as to give it a wedge-shaped cross-section. A blower was installed at the end of the hood on each side and delivered air through it to the tunnel portal where a narrow opening in the inner surface of the hood permitted the blast to be forced into the tunnel nearly parallel with its axis.

Trains pass through this tunnel in one direction only, and as the grade is up from this end they are usually drawn by two locomotives in front and one pusher behind. As soon as the forward locomotive enters the tunnel the fan is started. The large volume of air which is forced into the narrow space between the train and the tunnel lining drives the smoke and gas in advance of the locomotive so that its driver can keep the cab windows open and is supplied with an abundance of fresh, pure air. The second locomotive does not work in the tunnel, and the smoke from the pusher never reaches the front of the train. This arrangement is considered efficient and satisfactory.—*Black Diamond.*



PNEUMATIC LOGGING SAW

The accompanying cut, from the *Scientific American*, shows a compressed air "bucking-up" saw in use on the lands of the McCloud River Lumber Company, Siskiyou County, Cal.

The trees are felled by hand and then are cut into log lengths by this saw. A "swamping" crew precedes the saw and trims the felled trees, throwing the brush to one side to give room for the machines. The equipment consists of a traction engine equipped with an air compressor and air receiver, hose attached giving a working radius of 300 feet. The traction engine is moved under its own power to convenient points, when several trees are within reach. A heavy cross-cut saw is actuated by a piston with a long stroke working in a small cylinder set in a movable frame, which can readily be attached to a log of any diameter. There are usually three of these frames for the one saw. The saw when started is left to work automatically while the two empty frames are being moved to new logs and attached ready to receive the saw.

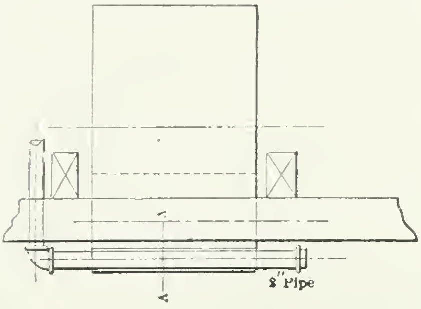
There is economy of time, labor and operating expense in the use of the apparatus. To run it requires nine men, and the average daily cost, exclusive of repairs, is $25. There is no apparent reason why a similar machine should not be used elsewhere when the conditions are favorable.

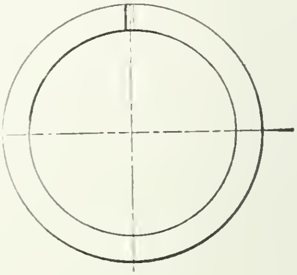
MACHINES IN COAL MINING

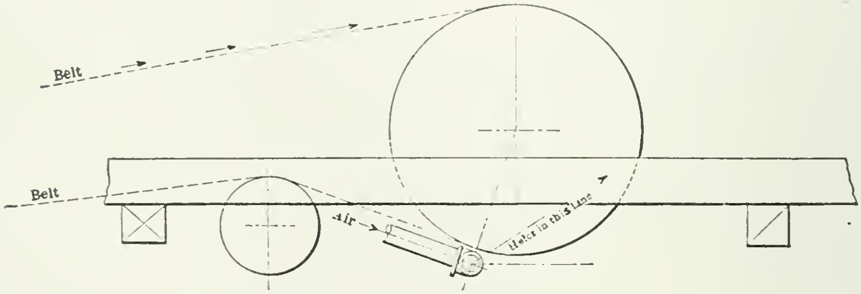
The report of the Mine Inspector of West Virginia gives some interesting figures concerning the use of machines in coal mining. In 1897 there were 55 machines getting out 600,000 tons—5.12 per cent. of the total output. In 1905 there were 1,158 machines, which got out 10,000,000 tons—32.75 per cent. of the total. The number of employes connected with the operation of the machines increased from 652 to 10,137, averaging about 10 to the machine.

A DEVICE FOR CLEANING CONVEYOR BELTS

Compressed air for removing wet and sticky materials from belt conveyers has been found effective when the usual method depending upon the use of brushes has failed. The device illustrated in the sketches here shown has for some time been in use at the Cananea Consolidated Copper Company's works at Cananea, Soñora, Mexico, and at the Old Dominion Copper Mining and Smelting Company's plant at Globe, Arizona. As far as known, all credit for the method and its application is due Charles F. Shelby, superintendent of the reduction division of the Cananea Consolidated Copper Company.







The device depends upon the impact of compressed air; the method of application is clearly shown in the sketches. Air under a pressure of 90 pounds is brought to the belt at a point immediately below the return pulley. The pipe is provided with 1/16-inch holes spaced by ½-inch centers, on the side opposite the belt and extending the entire width. The force of the air escaping through the 1/16-inch holes effectually clears the surface of the conveyor.—*Engineering and Mining Journal.*

This device when in use will of course get rid of a lot of air, but it of course is only used a few minutes at a time and at infrequent intervals.

SUPPRESSION OF DUST IN MINING

In connection with the recent rule issued by the New South Wales Mines Department, compelling the prevention of dust in metalliferous mines, Tyree Ltd., George street, Sydney, are urging the claims of their patent automatic spray. In some instances mine managers have got the idea that their present drills must be displaced by those having water spray attachment; but all that is required by the new rule is that "No hole shall be bored or drilled by machinery underground, unless a jet or spray of water is directed and kept directed into or about the hole, etc." For this purpose the Tyree spray is claimed to be admirably suited, the machine being portable, enabling it to be placed close to the face, or at any distance from it, with pipes to lead to the face. The consumption of water is also very small. The mechanism is simple, consisting of a cylinder containing the water, and a container for the charge of carbide which generates the force which drives the water from a spray nozzle. After the water has been exhausted, the acetylene gas generated in the drum can be used for lighting purposes, so that from the one charge of carbide both spraying and lighting can be accomplished. Besides these two purposes, the Tyree spray can be used for disinfecting the mine.

SINGLE-ECCENTRIC MEYER VALVE GEAR

By H. V. Haight.

The accompanying drawings illustrate a Meyer valve gear in which both main and cut-off valves are driven from a single eccentric. This gear is used on the steam cylinders of straight-line air compressors.

Referring to Fig. 1, it will be seen that the main valve is driven by pin *C* on the eccentric strap, while the cut off valves are driven by pin *D* on a rocker, which in turn is driven by pin *B* on the eccentric strap. The rocker is pivoted to the pillow block at *A*. This style of valve gear not only does away with one eccentric, one eccentric strap and one rocker, but it enables all the pins to be supported at both ends and placed so that the bearings are in

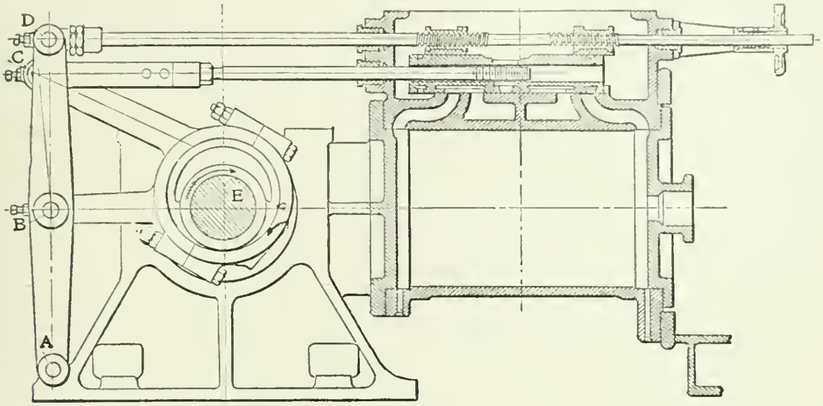


FIG. 1

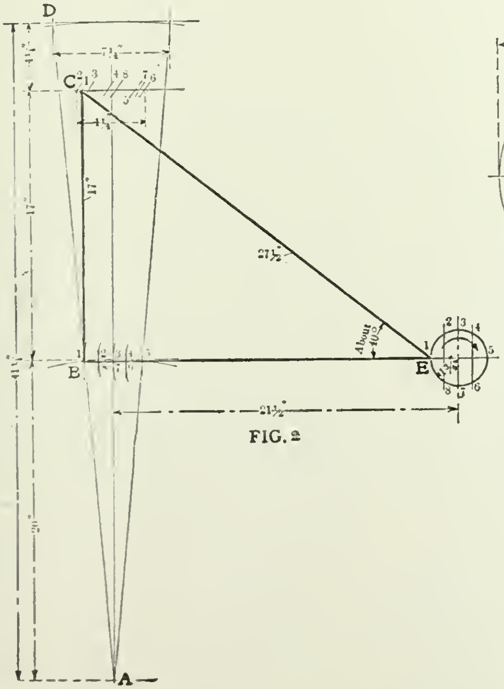


FIG. 2

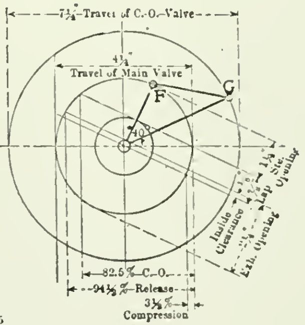


FIG. 3

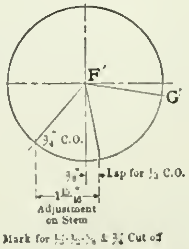


FIG. 4

Single Eccentric Meyer Valve Gear.

direct line with the stresses, and there is no twisting action on the rocker. The cost sheets show this style of valve gear to be cheaper than the ordinary style using two eccentrics and two rockers.

It will be noted that the machine runs "under." In order to make it run "over" it would be necessary to drive the main valve from the rocker and the cut-off valves from the eccentric strap, which makes an awkward construction and does not give as good a valve diagram.

LAYING OUT THE GEAR.

The method of laying out a valve gear of this kind would be about as follows:

In laying out the cylinder, the length of the ports will be made about three-quarters the diameter of the cylinder, and the width will be be made such as to give a velocity of 4000 to 5000 feet per minute. The steam opening will be made about three-quarters of the width of the port. The trial valve diagram for the main valve may then be laid out. For air compressors the valve has no lead and the compression is made small. The point of release will depend somewhat on the piston speed. The inner part of the valve diagram in Fig. 3 shows suitable percentages of cut-off, release and compression for a valve gear for this purpose. Having obtained the travel of the main valve, the next step would be to make the valve-gear layout, Fig. 2. An even figure would probably be chosen for the throw of the eccentric, which might bring the travel of the main valve slightly greater or less than that in the trial valve diagram. The final diagram may now be laid out. The angle between *B—E* and *C—E*, Fig. 2, gives the angular advance of the virtual cut-off eccentric, while the diameter of the outside circle in Fig. 3 will, of course, be made equal to the travel of the cut-off valves, as shown by Fig. 2.

Fig. 4 is then laid out by making *F′, G′* equal and parallel to *F, G*. The other positions for *F′, G′* are drawn for the minimum and maximum cut-off desired.—*American Machinist.*

A special meeting of the American Society of Mechanical Engineers will be held in New York, October 8, to act on a proposed merger of the society with the Mechanical Engineers Library Association.

DEVELOPMENT OF THE AIR BRAKE

None of the safety devices and appliances, as they are in use to-day, sprang "full panoplied" into existence. For example, while the Westinghouse air brake is known wherever a rail has been laid, few may be aware of the fact that, though in certain essentials it is the same device with which George Westinghouse revolutionized train operation nearly forty years ago—it was first used on the Pittsburgh and St. Louis ("Panhandle") Railroad, on the "accommodation" between Pittsburgh and Steubenville, in the year of its invention, 1869—it is as far ahead of the original as are the wonderful achievements of the locomotive builders of to-day in advance of the first railroad engine. Nevertheless, the performances of that first air brake were so satisfactory that its introduction in the passenger service of the various railroads followed almost immediately. First came the "straight air," which had on the locomotive its compressor and reservoir, from which the air was forced, at the will of the engineers, through the "train pipe" of each car and through the lengths of hose that coupled it from car to car, to apply the brakeshoes. Its shortcomings were that the perishable rubber hose was likely to burst, and so render it inoperative; and that, in the case of a parted train, the half to the rearward of the point of separation was left without braking power.

Then followed (1873) the "automatic brake," which, in addition to having a main reservoir on the locomotive, had an auxiliary storage reservoir on each car; it also reversed the actuating process of the "straight air," in that the train pipe was kept filled with air and applied the brakes when the air was permitted to escape, or when it escaped through a "parting" accident to the train. It was quicker and more efficient than the "straight air"; could be operated on either section of a parted train, and put the possible application of the brakes in the hands of train crew and passengers, instead of leaving the entire brake control with the engineer.

The successful performance of the automatic brake on passenger trains suggested to some of the Rocky Mountain railroads the advantages that would be derived from its use on freight trains, particularly on account of the very heavy gradients of the many miles over which their traffic was moved. The early experiments were so highly satisfactory that, by 1886, it practically controlled, in place of hand brakes, all of the freight traffic on the Trans-Missouri railroads.

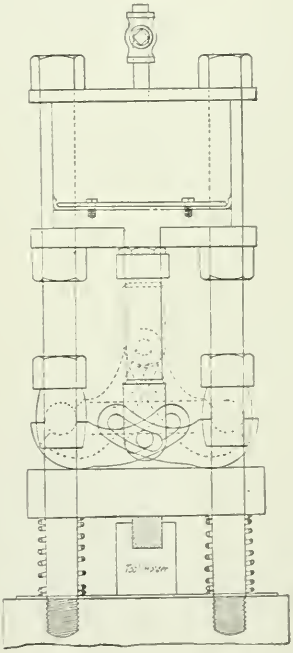
The rapid increase of railway traffic at this period drew attention to this successful experiment, and resulted in the gradual creation of a sentiment that it would be highly advantageous to control all freight trains by power brakes. The matter was placed in the hands of the Master Car Builders' Association for examination and tests, and under its auspices were made what are known as "the Burlington trials."

The performance of the automatic was entirely satisfactory for all ordinary service; but when applied in emergency the front brakes went on so much more quickly and with so much greater force, than those upon the rear of the train as to cause highly objectionable, and, under certain conditions, destructive shocks—the rear portion, weakly braked, running into the front portion. The committee, therefore, recommended that further tests be made, to give the inventors opportunity to overcome the defects. The high speed brake resulted, which within the last few years has been fitted to all of the fast passenger trains, while many roads use it upon all passenger equipment.

With the lengthening of trains, the limitations of the automatic brake, in service work, were found; and it became apparent that some improvement in the direction of securing rapid serial application there, as well as in emergency applications, was a necessity of satisfactory brake operation. After a series of expensive experiments there was finally perfected what is called the Quick Service Brake, because of its capacity for rapid serial application in both "service" and "emergency applications." The result is obtained by substantially the means described in connection with quick-acting brakes; with the new device brakes can be applied, in "service" more quickly on a hundred car train than upon a fifty car train with the automatic type, and the brakes are also applied with substantially equal force on the first and last cars of a long train—which was not the case with the automatic brake, those upon the front portion being applied with somewhat greater force than those upon the rear.—*Warwick S. Carpenter.*

PNEUMATIC TOOL CLAMP FOR WHEEL LATHE

The modern high-speed steels, modern as dating almost from the present century, with the possibilities of rapid chip-making which they carry, have stimulated the railroad shops to active competition, and some of the best results on record have been made in these shops. It is not easy to make comparisons of actual achievements except upon precisely similar lines of work. It happens that in all railroad shops there is one job which is common to them all, and which affords an excellent opportunity. This is the turning of the tires of locomotive driving wheels, in which there has been more or less of rivalry between the shops and accordingly considerable attention has been paid to the details of the operations involved, with a view to the shortening of the time.



The *Railway Master Mechanic*, from which the accompanying cut was taken, says that the average wheel lathe man consumes from five to six minutes each time that he changes tools, and as it is not unusual to change five times for a pair of wheels, thirty minutes is used in the operation, which is practically lost time. In order to reduce this time as much as possible, Mr. F. C. Pickard, machine foreman of the Pere Marquette shops, at Grand Rapids, has devised a pneumatic appliance for raising and lowering the tool holder plate on a driving wheel lathe, to take the place of the usual four studs and nuts which are tightened with a wrench.

The device as shown by the illustration consists of a 7½ by 5¼ inch air cylinder, anchored by two stud bolts to the tool column, the piston operating two slotted cams which raise or lower the tool holder plate, according to the position of the piston. When the piston is down, the plate is forced against the tool, holding it firmly in position by air pressure, and when raised to the position as shown by the dotted lines the tool is released and can be freely removed. The coiled springs under the tool plate force it upward when pressure is released. The piston moves the tool holder plate ½ inch.

For a tool rest or holder, a piece of steel 2¼ by 3 inches is used and is slotted lengthwise along the top for receiving a piece of self-hardening steel 1¼ inches square. This not only saves steel, but gives a greater bearing on the tool rest.

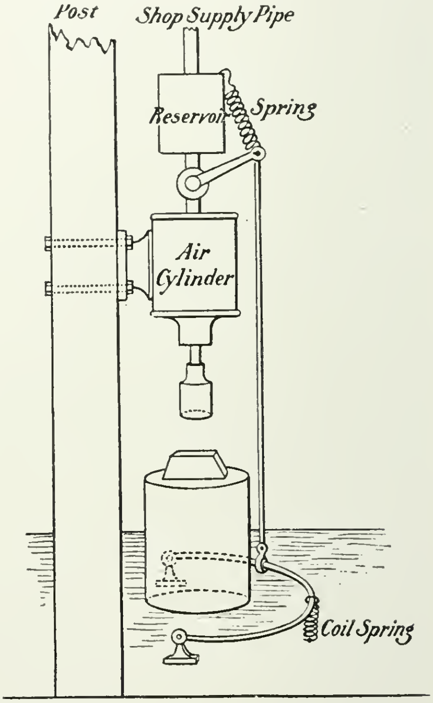
By using this appliance, lathe tools can be changed easily in one minute without the exertion required in the usual method, and the trouble resulting from the wrench slipping and studs breaking is entirely avoided.

The British Oxygen Company, of London, Birmingham and Manchester, have acquired premises at Newcastle, where they intend shortly to open a branch of their business for the supply of oxygen in the North of England. A large plant for the production of oxygen is now being erected at Newcastle, and it is expected that it will be in operation early in the autumn. The plant will produce oxygen by the liquefaction of air, and it is being constructed under the patents of Dr. Carl von Linde, whose British rights have been acquired by the company. Dr. Linde's process consists of an apparatus in which air is first completely liquefied by his self-intensive system and then, while obtaining almost complete transference of heat from the compressed air entering the apparatus to the liquefied air, the liquid is submitted to a special process of rectification by means of which oxygen of any desired degree of purity can be obtained.

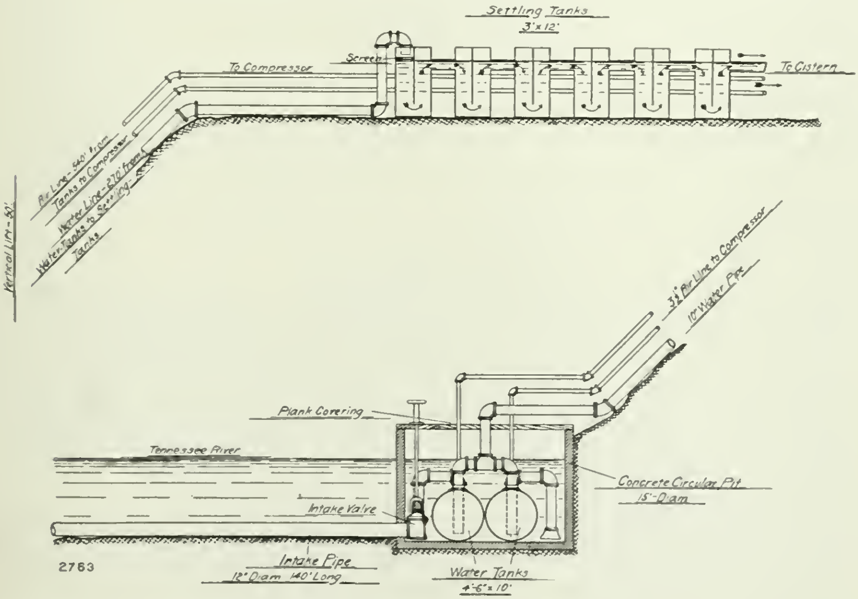
A CHEAP HOMEMADE AIR-HAMMER

The sketch here reproduced from *Railway and Locomotive Engineering* is an apt illustration of how an enterprising man of the shop who wants to do things is apt to take advantage of the presence of a constant supply of compressed air, and by the aid of simple and inexpensive devices make its readiness and handiness available for many purposes. The hammer was gotten up by Mr. William Gunmere, air brake expert in the Columbus, Ohio, shops of the Hocking Valley Railroad, and the sketch, although so simple, really tells us all about it.

The air cylinder formerly did duty on a locomotive in operating the driving wheel brakes. It is bolted to a post, as shown, and the lower end of the piston rod is fitted with a round chunky piece of steel for a hammer head. There is a coil spring in the cylinder which normally holds the piston up, as shown. Under the hammer is the anvil, supported on a large, round block of wood like a chopping block in a butcher shop. There is a pipe in the top cylinder head connecting it with the air reservoir and in this pipe is a three-way



plug cock as used in air brake service, to let air into the cylinder or to exhaust it, according as it is moved to the "application" or the "release" position. The feed valve reservoir above has been discarded after years of service on the road. It keeps a sufficient quantity of air close at hand to fill the cylinder quickly without making the shop supply pipe gasp for breath every time the hammer strikes a blow. The lever of the plug cock is connected by a rod to the treadle below. The treadle is made of ¾-inch gas pipe and extending halfway round the block and about 3 inches off the ground, is handy for the operator in any position. The hammer is used largely for straightening brake rods and other crooked material. It is a useful thing in its line and does a lot of work one way and another. We must confess we would have liked it better if it had been piped to have the air lift the hammer as well as to press it down. A thing used only intermittently as this is uses comparatively very little air and is always ready.



RETURN AIR PUMPING AT CHATTANOOGA

Manufacturing plants, iron mills, tanneries, etc., located near lake or river, usually get their water supplies from these sources by means of direct-acting steam pumps. The distance from boiler to pump is, in most cases, considerable, and the steam pipes are usually exposed. As a result, the steam condensed in the pipe becomes a serious item, increasing the steam consumption charged to the pump and reducing the pump efficiency to a very low figure. This condensed steam, furthermore, is likely to freeze in cold weather, involving trouble and delay, if not actual bursting of the pipes.

The Chattanooga Coal and Iron Company, Chattanooga, Tenn., until recently obtained their water supply for furnaces and other requirements in the mill from the Tennessee River by direct-acting steam pumps. The water in this river is extremely muddy during practically the entire year, offering serious difficulties in keeping the pumps packed. Pumping under these conditions is a very annoying and expensive problem to the company—a fact that is true with other companies similarly situated. The annual maintenance bill for their pumps was something startling. Pistons, piston rods and valves had to be replaced at very short intervals. The company diligently searched the entire market for a better and more efficient method of handling their water supply and fortunately heard of the Return-Air system of the Ingersoll-Rand Company. After close and careful investigation of this system, they concluded, since there are no wearing parts in tanks (which are usually submerged), no separate attendant at the tanks, no separate building required for air compressors and the efficiency of the system high, to give an order for a Return-Air Pumping System.

The capacity of this plant is 1,000 gallons of water per minute. The equipment consists of two Class "RC" air compressors, size 12 and 16 x 16 inch, two switches placed in their main power house, and a set of tanks 4 feet 6 inches x 10 feet, with check valves. Note that compressors and switches are installed in duplicate. The cut shows the location and arrangement of tanks, air and water lines, vertical lift and distance between tanks and compressor and also between tanks and water discharge. As the water passes through the settling tanks the flow is retarded and the dirt in suspension collects at the bottom, thus leaving the water clear as it enters the cistern. From the cistern it is pumped to a stand pipe near the smelters. If the river water was clear it could just as well be pumped direct to the standpipe by the return-air system.

An interesting feature to be noted is that the Tennessee River is subject to rises of 30 to 40 feet; but the system operates with perfect satisfaction, being entirely independent of the submergence. The plant is giving the utmost satisfaction.

O. S. SHANTZ.

PUMPING SAND BY COMPRESSED AIR

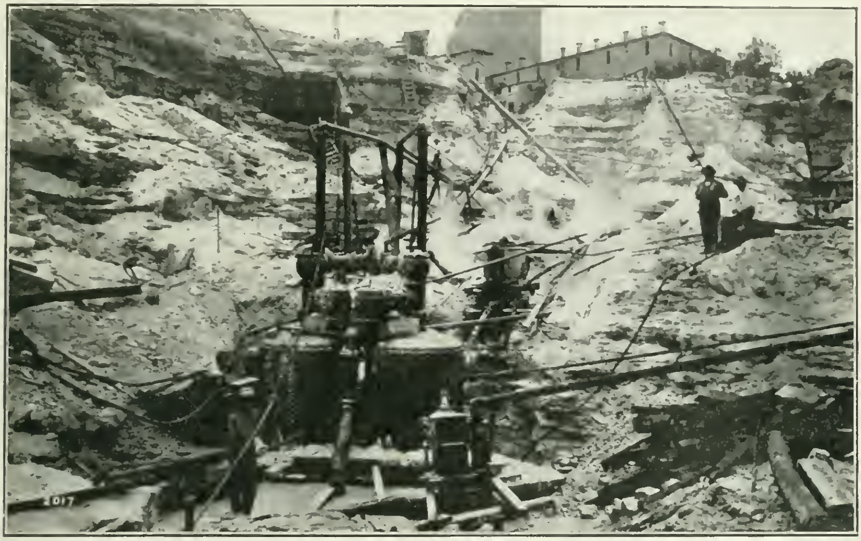
A novel and highly successful application of compressed air is found at the plant of the United States Silica Company, Ottawa, Ill., about eighty miles from Chicago. At this point is an immense deposit of silica sand, very fine, almost snow white, and of the best grade for glass-making purposes. The property of this company at this place has been worked for some years and at present the excavation is about 800 feet long, 600 feet wide, and with a maximum depth of about 100 feet.

The cost of removing this sand and hoisting to the plant on the surface has been steadily increasing with the depth. Recently a point was reached at which a shut-down of the property seemed imminent unless some more economical method of lifting the sand could be devised. A contract was placed with the Pneumatic Engineering Company, a department of the Ingersoll-Rand Company of New York, for the installation of a Return Air pumping outfit especially adapted for this particular work. This system involves a direct displacement of the contents of a tank by air under pressure, this air being in turn returned to the compressor for re-compression. Advantage is thus taken of the expansive force

GENERAL VIEW OF THE SAND PIT OF THE U. S. SILICA COMPANY, OTTAWA, ILL.

of the air—a feature distinguishing the Harris "return air" system from other pneumatic displacement pumps.

In the Ottawa plant a sump was dug in the lowest part of the sand pit, and here were placed two steel tanks 5 feet in diameter and 5 feet in height. Upon these are mounted the connecting pipes and valves by which the tanks are filled and discharged in alternation. A double air line of 3½-inch pipe leads to the automatic switch and compressor in the engine room on the brink of the pit. The compressor is a Rand, Class "C," straight-line, steam-driven machine, running under 80 pounds steam pressure and delivering air at a pressure of 80 pounds at the maximum of the pumping cycle. The discharge pipe from the pump to the sand bin is a 7-inch pipe and the total distance of delivery is about 400 feet, with a vertical lift of 110 feet.



THE HARRIS PUMP AT THE U. S. SILICA COMPANY'S PLANT, OTTAWA, ILL.

The method of excavating the sand is at present as follows: A constant flow of water which enters the pit on all sides from springs is collected in a sump which is the source of supply for a small duplex steam pump which takes the water and discharges it through a hose and nozzle. The stream is played on the walls of the pit, washing the sand down, and the mixture of sand and water is directed into a box beside the main pipe. The pump suction pipe enters this box and the partial vacuum created in the tanks draws the sand and water into the tanks, from which it is discharged by compressed air in the next cycle through the delivery pipe to the bin above. The sand mixture varies in quality from one of 5 per cent. of sand to one of 65 per cent., by weight. The average performance of the pump is 50 tons of sand alone raised per hour, or 500 tons of sand per ten-hour day. The work done by the pump will be further appreciated when it is considered that the supply of water entering from the springs is from 300 to 500 gallons per minute, all of which, also is discharged with the sand through the pump.

It might naturally be expected that the rapid pumping of such an abrasive material as sand would soon destroy the pump mechanism; but after an operation of several months there has been found to be no appreciable wear on this system. On top of each tank there is a check valve preventing the return of the material in the discharge pipe. This is of the simplest form, consisting of a rubber-covered ball resting on a ring seat; and inspection has shown that while the seats have worn uniformly and present the appearance of highly polished turned rings, the balls themselves show no wear whatever. The pressure-controlling valves are located in the engine room above, and at no time are in contact with the material pumped.

This system works continuously; during the day it pumps sand and water in mixture; during the night it pumps water alone, keeping the pit empty and ready for resumption of operations on the following day. It is found that the maximum volume of water entering the pit can be handled when the pump tanks are filled and emptied at the rate of about one a minute.

The introduction of this method of pumping simplified the problem of removing the sand in many ways. Its operation calls for three men: the engineer looking after the compressor, who also cares for other machinery in the surface plant; the pump attendant, whose duty it is to see that the flow of sand and water is properly directed to the gathering box; and the hose man handling the stream of water for removing the sand from the walls.

The sand mixture is discharged from the pump into the receiving bin at the surface, where it is allowed to settle; the water flows off through a waste-way. This partially dried sand is then removed from the bins and put through the usual process of drying and separating. The operation of the surface plant offers no unusual features; but the introduction of this pneumatic system of pumping in the pit has been the solution of a serious problem which was confronting all the sand producers of that section. The illustration shows the interior of the pit with the pump in position and the pipe lines leading to the plant on the brink.

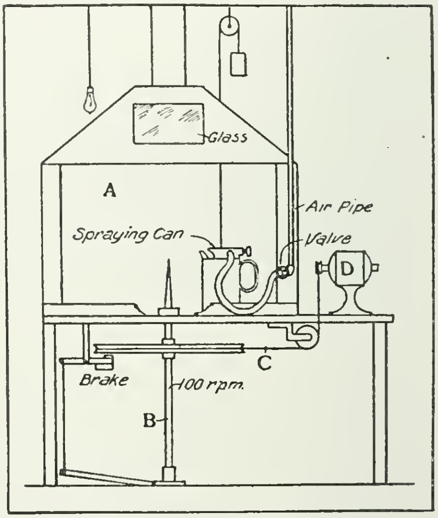
The system which the new method replaces was, briefly, as follows. The work was carried on in three levels. The sand was washed by the hose to the lowest level, or sump, where it was hoisted by a vacuum steam pump to the second level. Here a single outside-packed direct plunger pump lifted it to the third level, from which it was elevated by a scraper conveyor to the bins. The seepage water was handled at night by a duplex steam pump.

All of these pumps were supplied from the surface boiler plant through long steam lines, and the steam and fuel consumption was enormous, due both to the excessive pipe condensation and to the wasteful non-expansive features of the pumps. Furthermore, the whole system was liable to freeze up solid in winter. The depreciation on the machinery involved was very heavy, the plunger pump especially wearing rapidly under the abrasive action of the sand mixture and losing what little efficiency it had. Fuel and maintenance costs were enormous.

With the pneumatic sand lift the only long steam line is the small one to the hose pump. The rest of the system, being under pressure, is proof against freezing, and its freedom from abrasion has already been noted.—*Lucius I. Wightman.*

COMPRESSED AIR JAPANNING MACHINE

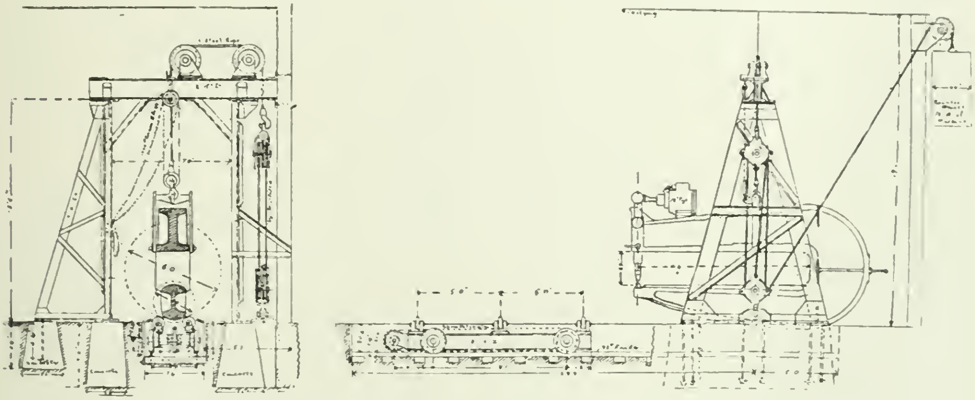
This machine could probably be used to advantage in any factory where japanning is done, as by its use twice as much work can be turned out and many articles can be given a more even coat than is possible by the dipping process, or by hand work. It is especially useful for round work but can be used for any article not too large.



A wooden hood A is left open at the front, and is provided with a pipe at the top to carry away the fumes. Four glass windows are made in the top, and one or more electric lights are arranged so as to illuminate the work. A vertical shaft, B, is revolved by means of a cord, C, which runs to an electric motor, D. The shaft is pointed at the top to receive a flat piece of wood for holding the work, nails being driven in the wood to accomplish this purpose.

As the work revolves it is given a coat of japan, by means of the spraying can, which contains the japan and is connected to an air hose, as shown. These cans can be purchased ready to use, and are provided with a special compressed air nozzle, which atomizes the japan and deposits it on the work. The japan used for this purpose should be thinned with turpentine before using, as it would otherwise make an uneven coat.

The machine should never run more than 100 r. p. m., and unless the work is very small 80 r. p. m. would be better. If it is run too fast the japan will be thrown off the work by centrifugal force. About 30 pounds air pressure is sufficient, but a greater pressure may be used by throttling down with the valve.



END AND SIDE ELEVATIONS —HORIZONTAL RIVETER

A NEW COMPRESSED AIR RIVETER.

The necessity of a large riveting machine is felt in every shop where boiler and structural work is handled. The vertical riveter is a satisfactory installation for all classes of work but is expensive on account of the special building and accessories that are required.

With the idea of furnishing a riveter with the capacity of the vertical type and without the excessive cost, the Albree Iron Works Company, Allegheny, Pa., have recently employed a new method of installation with considerable success.

A compression riveter with 10 feet 6 inches reach is suspended from a wooden trestle 13 feet 6 inches high by a 1 inch steel rope over two sheaves to a block, and falls balanced by a counter weight. A heavy chain and block are within easy reach of the operator for shifting the position of the riveter.

Beneath the riveter, a pit is located 24 inches deep and 29 feet 6 inches long, in which is laid a track of 2 feet 9 inches gauge. On this track is placed a steel car with a sprocket wheel and chain for moving the car when carrying heavy loads. Three rollers are placed on each side of the car to support cylindrical boiler shells.

The method described will cost about one-fourth that of a complete hydraulic installation and about one-half of a vertical compression riveter for doing the same class of work. There is also a considerable saving by using compressed air instead of hydraulic power, and while there still exists a preference for the hydraulic riveter it has been found that the work is not superior to that of the machine operated by air.

Twenty-five years ago the United States produced 27,000 tons of copper. The production during 1905 was practically 400,000 tons, or more than half of the world's total supply. The value of last year's output may be given as $160,000,000.

The uses of this metal are steadily growing. It is estimated that by 1920 the requirements of the world will reach 1,500,000 tons. The United States will probably hold its present place in the market. New deposits are opened from time to time. There are known districts yet undeveloped in the Western mountains, and Alaska is rich in copper. Mexico and Canada are copper countries and send the United States ore and matte for smelting, and pigs, bars and ingots for manufacture.

The increasing supply of the metal promises to keep prices within reasonable bounds, while the increasing demand fairly assures ample profits to the owners of copper properties.

THE GORDON DRILL ON THE RAND

The most notable event of recent years in the history of mining operations on the "Rand" in South Africa has been the advent of the Gordon rock-drill. This region has its peculiar labor, or, rather, race, troubles, and the drill is remarkable not only in itself as an invention, but also in the simplification of the task of operating it. The following very clear account of this drill, its operation and status, is taken from recent Consular Reports:

"The Gordon drill, lately introduced on the Rand, has been designed primarily for the saving of labor. Under present conditions, a boy —*i. e.*, Kaffir—puts in one 3-foot hole in a shift in the ordinary manner; whereas, by using this drill he can put in five holes. The drill is so designed that it can be operated in very narrow stopes, thereby saving the mining, tramming, hoisting, milling and cyaniding, etc., of much waste rock. For instance, should a reef be one foot thick, and, through lack of sufficient labor, the mine management is obliged to put in large drills for mining the reef, it is impossible to break a stope of less than from four to five feet. Under these conditions, the rock has a value of about 10 pennyweights; with the use of the Gordon drill the value of this rock or ore is greatly increased.

"It is anticipated that this machine will do away with 75 per cent. of the number of boys now necessary. The saving in cost is problematical as yet, but a conservative figure is 24 cents per ton for the 1,500,000 tons mined monthly, one-half of which amount is at present machine-drill mined.

"In appearance the drill resembles a piece of 3-inch pipe with a crank handle attached. It weighs about 55 pounds. Its cost of maintenance is slightly less than that of a 3¼-inch slugger machine. It drills a 36-inch hole in less than 30 minutes, including time required in changing steels. In the hands of a Kaffir or Chinaman, one machine will drill four to six holes, 36 inches deep, per shift; one white man is necessary for pointing, charging and firing the holes for five machines.

"The drill is fed forward against the rock face or bottom of the hole drilled, by air pressure, and hence needs no screw-feeding or shell. It moistens and ejects its rock cuttings automatically, without creating any dust whatever. It has no chuck bolts, the steel being loosely positioned in the chuck. It is encased in a 3-inch pipe and can not be tampered with by the Kaffir. It can be worked in as small a stope as a boy or Kaffir may crawl into.

"The machine is made of steel throughout; the column and arm with clamps weigh about 70 pounds and can be easily carried about and set up in about five minutes. It has no bolts nor nuts, simply wedges, so driven that they can not fall out when the machine is in use. Instead of a wrench, a hammer is used to tighten the parts. The clamps on the arm are of advantage in giving the drill a longitudinal movement of 17 inches in addition to the 12-inch travel of the machine, affording a forward or backward movement of 29 inches, and thereby doing away with the necessity of taking down and setting up of the column every second hole. The air hose is one-half the size ordinarily used, weighing only 30 pounds as compared with the 75 pounds for the 3¼-inch sluggers.

"The steel is forged to cruciform shape bits, and it is therefore impossible for the Kaffir to drill other than a round and straight hole, even when the ground is very seamy. Four steels are used to each 3-foot hole. The steel-dressing machine used in sharpening the bits will point 400 steels per day at the same or less cost than for a like number of 3¼-inch machine drills. The ordinary dirty and acidulated mine water is used in operating the drill, the head of which only is in the drive line; the consumption of water is about 1½ gallons for each 3-foot hole drilled. The reef air pressure of 70 pounds is acceptable.

"The white miner requires no knowledge of drills, but should understand how to break ground; the Kaffir or Chinaman is required only to change steels every few minutes, open and close the air-valve on the machine and turn the crank handle, none of which duties require any great intelligence on his part.

"Hollow steel is used, and the water is forced through the hole under a head of 50 feet, which is sufficient for keeping down all dust. In starting a hole, a 1½-inch bit is used, which is followed by bits of ⅛-inch less diameter, until the hole is bottomed out with a 1-inch bit. The drill strikes 400 to 500 blows per minute, with strokes varying from 7 to 8 inches."

The following from *South African Mines* gives an account of a series of trials of the Gordon drill, and in connection therewith it tells of the development and practical improvement of the drill since the first crude specimens of it were put out:

"The Robinson trials of the Gordon drill, extending over a period of eight months, have developed the weak points of the machine, particularly in relation to material and workmanship. When the fifteen machines were first put to use on the Robinson they were not equipped with many of the features they now have. The features referred to are the automatic oiling arrangement, ratcheting crank handle for 2-foot stopes, improved water front head, etc. These parts were made locally, and unfortunately both the material and workmanship were not what they might have been. Properly made at home they will prove above criticism. Among the so-called weak points we find that the cylinders are made of mild instead of cast steel. True, the wear in six months is only one two-hundredth part of an inch; still, if the hard cast steel were used it would be practically nothing. On the other hand, the wear of big machine drill cylinders is five to ten times as great in the same period. Again, we find two pieces pressed together and riveted, whereas the better method, and that now employed, would have been to make the two pieces out of a solid bar or casting. The impact piece or anvil block also breaks quicker than it should because of the quality of steel used, and the temper given it. This, of course, is being remedied. The corresponding part in the big machine drills lasts only five to ten shifts. In several places brass castings are used instead of steel, as now proposed. Naturally, brass will not stand one-quarter as well as steel. But the really vital parts of the machine have given no trouble—we refer to the valve, air chest, piston, air feed, column, etc. The dust-allaying device, because of faulty local workmanship, is wasting more water than necessary; yet a series of tests made recently indicate that even then the water consumption for a 3-foot hole is only about 1.½ gallons. As this water is used over and ovel again by the machines on the lower levels, and is also useful in allaying the dust created when lashing, this consumption in a 100-drill mine will prove inconsiderable.

"The inventors have been aware of these weaknesses from the very start, early last summer, and they assure us that the machines now on the way out will not be subject to the criticisms mentioned—*i. e.*, there will be no such faulty material or workmanship as we have mentioned. In this connection it is not out of place to remark that the design of the machine has not been criticised, even though it is such a radical departure from what we know as a machine drill. It must be borne in mind that the Robinson tests have not been run under the best conditions in regard to air pressures. Instead of the generally accepted minimum of 60 to 65 pounds pressure, which is as low as any rock drill can do really good work with, the Gordon drill worked with a pressure frequently under 50 pounds. While a so-called mining condition, at the same time it is certainly not altogether fair in a test run. Another reasonable criticism is that one boy was employed on every four machines to bring in and take out 80 drill steels weighing about 400 pounds. To charge this boy against the Gordon drill does not seem altogether right, as under average mining conditions he would not be employed. If we eliminate him, the Robinson trials, as reported officially, show an efficiency of over 4.2 holes per native, or 25 per cent. more than reported. Moreover, of the four white operators employed by the mine, at least one knew nothing about breaking ground, and would not have been kept on to run big machine drills. This criticism is based on the comments made by the various mining engineers who watched all four men.

"Turning to the natives employed, we find that out of fifteen at least a third never averaged under six holes per shift, and some drilled seven to eight holes per shift at such times as the pressure was what it should be—that is, 60 pounds and over. This only confirms the experience of big machine drill operators, in that selected boys are better than the riff-raff of the mine usually given the newcomer. Still another point borne out by the Robinson mine figures, and lost sight of, is that holes put down with the Gordon drill ought to break more ground by at least 20 per cent. than the ordinary hand-drilled hole. This is obvious when it is borne in mind that holes can be drilled 10 to 20 per cent. deeper than those generally put in by hand, and also at least 30 per cent. greater in area at the bottom. It is therefore not quite fair to consider holes or footage only. Fathomage is manifestly equally important. Given a reasonable air pressure, say 60 pounds, at the working face, eliminating the native carrying 80 steels twice a day, and placing the drill in charge of average good miners, it would not be too much to expect at least five to six holes per native shift at the Robinson, the fathomage or rock broken being equal to that of six to eight hand hammer boys. That we are not very far out is confirmed by one of the officials, who has repeatedly remarked that the Gordon drill, in his opinion, is capable of putting down eight holes, which in fathomage would be equal to the work of ten hand hammer boys. We know of ten holes having been put in by a native, so eight is not too much to expect.

"In this connection we are reminded of a criticism made recently by the best-known rock drill agent here, to the effect that if the thousand big rock drills he had at work on these fields were kept track of in the way the Gordon drill was being watched and reported on, his business would fall off at least 90 per cent., if not altogether. This bears out our belief that the whole truth regarding the value of this Gordon drill will only become manifest after we have 500 or so at work on these fields. Once taken as a generally accepted factor, we will see more of the good points and less of the weak ones. We understand that on the basis of the Robinson trials the intention is to contract to keep the machines in repair for a fixed sum, the figure to be less than one-half of that now charged for the maintenance of large drills. The prevailing opinion is that this ought to be done very easily. We also learn that air consumption tests recently completed indicate that per inch of hole drilled the Gordon drill consumes only a third of the power required by the large machine drills; certain slight changes now made will reduce this still further. With these two factors insured, and discounting as indicated the results obtained at the Robinson mine, the real value of the Gordon stoping drill as a labor and money saver to the industry, is apparent.

AIR AS A CONVEYOR OF HEAT AND MOISTURE

The transmission of heat or of moisture by means of a fan blower is closely allied with the process of ventilation. In an ordinary fan heating system all of the heating surface is massed at the fan, whence the heated air is forced through ducts to all parts of the building. For normal indoor temperatures, the outdoor air at zero, the incoming supply must range in temperature from 100 to 150 degrees, according to the rapidity of air change within the building. The air thus becomes a medium by which the heat is transmitted to distant points.

The process of drying is only an exaggerated case of heating in which the temperature to be maintained greatly exceeds that required in a well-ventilated room. A supply of air sufficient to change the volume once in 8 to 15 minutes in the ordinary structure is all that is necessary to meet the conditions of good heating and ventilation, but a supply equivalent to a complete change in the free spaces within the dry room 60 or more times per hour is required in the lumber dry kiln. The temperature therein will range up to 150 or more degrees. Owing to its greatly increased absorptive power the air at this temperature greedily takes up and carries away the moisture in the exposed surfaces. The method of application and the temperature to be maintained depend entirely upon the character of the material to be dried.

Glue and gelatine require low temperatures and ample volume. Knit goods in the piece are dried by internal application of heated air under pressure which distends the piece, the air escaping through the meshes. Cotton, wool and the like are spread upon beds formed by covering with netting enclosed boxes into which the hot air is discharged and from which it can only escape through the material above. The materials now dried by hot blast are legion: asbestos, blood, bricks and clay, clothespins, eggs, leather, malt, milk, gunpowder, hair, soap, stove linings, sweet corn, yarns and a thousand other products of our industries depend upon the process for their successful production.

VACUUM FEATHER PULLER

It is stated that a new machine for plucking feathers from fowls promises to revolutionize the methods heretofore in vogue for this operation. The system is said to be along the line of the new vacuum apparatus now in use for cleaning carpets, etc. The freshly killed chick is put into the machine and suction does the rest and not a sign of a feather remains after the operation is completed. Whether a continuance of the operation would also skin the fowl is not stated. Former Governor Odell of this State is said to be interested in the invention.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

W. L. SAUNDERS, - - - - - Editor
FRANK RICHARDS, - - - Managing Editor
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GROWING ECONOMY IN COMPRESSED AIR PRACTICE.

The continued and rapid extension of the use of compressed air is a topic perhaps sufficiently familiar. The volume of compressed air used and the number of industrial enterprises in which it is now an indispensable agent have increased enormously even within the last decade; but more gratifying and more worthy of note is the improvement in air-compressing practice, the advance in the standards of performance as represented in the requirements of those who use the air compressed, and the success of the builders of air-compressing apparatus in satisfying these requirements. It happens that these matters have perhaps their best illustration and embodiment in our immediate neighborhood, and nowhere in the world in equal space is gathered such a collection of highly efficient and economical air-compressing machinery in actual and successful as in the city of New York.

There have been simultaneously employed upon the tunnel and railroad extension work entirely within the Greater City of New York and on the New Jersey shore directly across the North river, nearly 100 air compressors, with an aggregate free air capacity of 200,000 cubic feet per minute, a volume which would be represented by a cube with a side of 58 feet. The precise figures it is not necessary to give, but they are easily accessible, since it happens that all the compressors here spoken of, although selected and employed by a number of diffeffrent contractors, all fully informed as to the requirements and possibilities, and some of world-wide experience have been built by a single firm, who have complete records of these installations.

The gratifying fact in connection with these several plants is that they represent as a whole not only the most efficient and reliable, but also the most economically operated compressed air plants in the world. The driving of either of these tunnels or the excavating for the big railroad stations is of course in each case a temporary job, and it might easily have been assumed that it would not be wise or necessary to install anything but cheap machinery for the work. The machinery employed is, in fact, so cheap that in the saving effected in the cost of coal for driving them, as compared with the coal consumption of the usual compressing plants of ten or fifteen years ago, and all too numerous even to-day, they cost actually nothing, or entirely pay for themselves in a single year. This is not a random statement, but is based upon reliable information and careful computation.

It will be well to bear in mind the few essential points to be insisted upon as essential to economy in operating steam driven air compressors. Especially in these places are the conditions at the steam ends of the machines looked after, as here, after all, the greatest savings are effected. High pressure steam is used; the steam cylinders are compound and condensers are generally employed for all the steam used. The air-compressing cylinders also are compound or two-stage, with intercoolers between the cylinders, and aftercoolers are frequently employed. By these means high economy is effected both in the genration of th power at th steam ends of the machines and also in the employment of the power in the work of compressing the air, and cheap compressed air is the result.

"AT THE WORKS"

By R. W. Raymond.

I borrow the title of this article from a book which has recently appeared in England, and to which, by reason of both its individual merit and its representative character I desire to call the attention of students of the "labor question." The literature of this subject, voluminous as it is, still fails to furnish the body of clearly observed and accurately recorded data which is necessary to safe inductions of general value. Magazine writers, bound to make impressive, picturesque and readable articles; partisans, seeking to advance their own theories or interests; sentimental philanthropists, to whom every hardship is a wrong, and every radical change of the social order is a remedy; politicians, regarding every wave of popular unrest as an aid to their own private navigation—until the tide changes; governmental committees of inquiry, tabulating assertions as if they were facts, and seeking to draw conclusions which will offend nobody; boards of arbitration, whose object is peace through compromise, rather than justice at any cost—these are too often the sources of our knowledge of the labor problem. Assuming them all to be sincere and honest (which certainly not all of them always are) they are still affected by the lack of quantitative measurements and the substitution of emphasis for weight in their statements of the fundamental elements of the problem. As a result, we are distracted by the advocacy of impracticable or ruinous remedies for non-existent, unavoidable, transitory or self-correcting features of the industrial situation.

What we want above all is *facts*. Are the poor really growing poorer, while the rich grow ever richer? Is the freedom of individual contract, protected and enforced by law, achieved by so many centuries of struggle and progress, a failure? Is socialism our only refuge from anarchy? These profound questions are daily treated as if they could be settled by eloquence, enthusiasm, or even brute force, without any thorough preliminary inquiry into the facts.

In this hasty and hysterical condition of public opinion, every calm and just, as well as sympathetic, report of the simple facts is most welcome; and to this class belongs the little book to which I have referred. Lady Bell, the author (already known in literature through several works of fancy and criticism, quite unlike this one), is the wife of Sir Hugh Bell, the son of Sir Lowthian Bell, and now the president of the Iron and Steel Institute, as well as lord lieutenant of the North Riding of Yorkshire. Those who know him need not be told how worthily his wide knowledge, genial sympathies and practical wisdom have enabled him to continue the work of his illustrious father. But, in my judgment, he needs no illumination, and suffers no eclipse, from his father's fame. I regard Sir Hugh Bell as one of the ablest men in England.

The wife of such a man may be (like Lady Lyell) his constant and coördinate co-laborer. Or, she may have her own distinct sphere of interest and influence. Lady Bell seems to have pursued a middle course. While reinforcing her husband in the manifold social duties of his position, she has made, for nearly thirty years, a close and sympathetic study of the actual conditions and lives of the operatives in the iron industry of Middlesbrough. Of this she now publishes the result. Her own description of the scope of her book is at once without any inquiry into the facts.

"I have not attempted to deal with the larger issues connected with the subject . . . with the great questions involved in the relations between capital and labor, employers and employed; I have tried but to describe, so far as it is possible for an onlooker to do so, the daily lives of the workmen engaged in carrying on the iron trade of this country in one of its centers of greatest activity."

Let us fervently give thanks for a piece of work so modest, yet so thorough and sincere. However tempted, I shall not, on this occasion, at least, mar my praise of it by using it in support of any views—even my own!—on the "labor question." All I would do now is to recommend the perusal of it to all honest students of the subject.

In successive chapters, the book treats of the Genesis of the Town; the Process of Ironmaking; the Expenditure of the Workman; Illness and Accidents; Old Age, Joint Households, and Benefit Societies; Recreation; Reading; the Wives and Daughters of the Ironworkers; Drink, Betting and Gambling. These topics are treated with keen perception and practical wisdom, as well as graphic descriptive power. Lady Bell must be recognized as of the select company who set forth "things as they are."—*Engineering and Mining Journal.*

COMPRESSED AIR IN COAL MINES

The following interesting discussion which occurred at a recent meeting of the Engineers' Society of Western Pennsylvania, touches several topics of special interest to our readers. The subject under discussion at the beginning of the portion here reproduced was the long-distance transmission of air in the mine.

Mr. Lewis: We hardly ever get several miles in, but sometimes go as far as 10,000 feet. Following the pipe, it may be farther. We do not get the air in very successfully on long distances.

POWER LOSSES OF THE PORTABLE COMPRESSOR.

Chairman: I was in one of the mines in Wheeling some time ago, where a small truck, on the same main track, carrying a small electric driven air compressor, was used to supply air to the punching machine. This truck was carried within 30 or 40 feet of the puncher and moved about from place to place. This does away with the necessity of carrying the air through such long pipe lines.

Mr. Myers: That has been tried at different places, but the great trouble has been that you do not have water for cooling the compressor, and the air in the mine is charged with coal dust and it gets into the cylinders with the air and cuts them.

Mr. Lewis: It is a long way around the bush to first generate the electricity outside, take it inside, stand the losses on that, and also the losses which must necessarily occur with compression on a small scale, which increase quite rapidly as you go down the line. A big compressor working with compound steam and on compound air, thus cutting down the clearance loss to two atmospheres instead of five in the air cylinder, will run with very good economy. But the kind of compressor you could run around on a buggy and drive with a motor would be a very wasteful machine in itself, and driving it by a small motor through the wire would carry also all the loss of a small motor and transmission. This in addition to the point you mentioned, that it is a mighty poor place to run a compressor.

PLACE FOR THE COAL PUNCHER.

Mr. Schellenberg: I might say of the punching machine that it can work where the large electric machine could not work, that is, where the roof requires propping. An electric machine has got to be big nowadays or it is not economical. Such a machine requires about 12 feet free space to move one frame over the other, and the roof is in very many cases not good enough to stand such an open space unpropped. With a punching machine one can go between props just as a hand miner does. But all the coal is not mined by machinery. You can not mine out between rooms with machinery. So there is a disposition to leave rib coal in the ground—that is, to mine out what they can get with machines and let the rest go. It requires some hand mining to get all the coal. Then there are no machines in the coke regions. They do not undermine there; they blast from the solid face in narrow headings and rooms, and take out all the rest of the coal systematically in well-ventilated retreats.

Mr. Lewis: That coke region is rather a special condition, as they do not care how small the coal is.

Mr. Schellenberg: Machine-mined coal is never as large as hand-mined coal was or is, because it is slaughtered with the powder in heavy blasting.

J. M. Armstrong: It is also followed by a different class of miners than the hand miners of a number of years ago.

PUMPING A FLOODED MINE.

H. W. Myer: There was a unique occurrence related to me the other day relating to a case where a mine was flooded. The shaft was 150 feet deep and the mine was flooded as well as the shaft. They drilled a hole near the shaft 12 inches in diameter, drilled it down to and through the coal and about 150 feet deeper. Then they placed an 8-inch pipe in this hole without casing, and on the outside of the 8-inch pipe a 3-inch or 4-inch pipe, with an elbow extending up under and into the other about 2½ feet. This outfit was lowered into the hole to the bottom of the 300-foot hole. Then they connected a 3-inch pipe with a compressor temporarily set up and forced air into that pipe with 80 pounds pressure. They found that they could lift water out of that 12-inch pipe in a solid stream and lower the water rapidly, and did so until the water was lowered to the level of the coal; then it ceased to work. And it was very simple.

Mr. Myers: That is on the principle of what they call an air lift.

Chairman: I saw half a dozen discussions of the air lift in the *London Engineering*, I think it was, and nobody seemed to give even

Mr. Schellenberg: I can say confidently and a good theoretical discussion of it.
without any favor of any patentee that the easiest way to unwater a shaft on a large scale is to dip it out with boxes on the cages. There is no patent on it. It has been done in the anthracite regions as a steady way of pump-shaft work. I had the experience of unwatering a shaft that way and it worked very well. The boxes filled themselves from the bottom; and a little wooden lever was constructed to knock at the top, and lifting a gate on the box, to let the water out in a trough. It is relatively cheap and you can rapidly get and lift a full load of water.

Mr. Lewis: You have the advantage of lifting nothing but water; all the rest runs in balance.

Chairman: Does anybody know whether pulsometers have been used?

Mr. Schellenberg: They are very wasteful of steam, but will raise any kind of water and grit of any kind.

Mr. Myers: One of the troubles of the pulsometer is that when the pump sucks dry you have to reprime it; it will not pump automatically; at least, that is my experience.

VENTILATION.

Mr. Schellenberg: Compressed air is a very good adjunct even where they do use electricity. Anybody that has a compressor likes to hold on to it and use it for supplementary pumping in a small way; and it can be carried down to the very smallest. It can be used for a little automatic pump for unwatering a room in the bail hole instead of running a wagon in for bailing into. That cheap little air pump seems to have gone out of use. It is described best as a half-barrel beer keg, the bottom replaced by a performated copper bottom; on top is a balance for a valve that a float may open. When the water rises up inside it turns on the air. There is ⅛ inch of air only turned on that drives all the water through a little pipe to where it discharges itself by gravity, and then lets the valve seat itself; it may work day and night without any attention.

Then where entries are driven forward and there is compressed air in the mine, the steam pump can be followed up and used with air very favorably. And "sparking" electricity, it may be mentioned, can not be used in gaseous mines for any purpose, under present law.

VOLUME OF AIR REQUIRED FOR VENTILATION

Theoretically a miner working under ground requires only 6.5 cubic feet of fresh air per minute for respiration, the absorption of moisture and the dilution of carbonic acid gas. This, however, assumes that all air after having been breathed is immediately removed without mixing with the surrounding atmosphere, a condition impossible to fulfill. Considering that the permissible vitiation of the air by the carbonic acid is 6 parts in 10,000, it will be found necessary to provide 66 cubic feet of air per minute to dilute and carry away the 0.8 cubic foot of carbonic acid produced per hour by one man. In this light it is evident that, although an average man at work breathes only about 0.43 cubic foot of air per minute, the amount necessary to carry away the gases given off is the really important consideration. Where explosives are used another element enters into the question, and proper provision must be made for this when determining upon the means for ventilating the workings. The problem is more difficult, of course, when all or a part of the workings are "blind"—that is, where a level is run in like a tunnel and has but one outlet. This makes any sort of natural circulation out of the question, and requires an extensive system of piping and fans. Not only must fresh air be continually supplied in sufficient volume, but the vitiated air must be removed.

ATMOSPHERIC HUMIDITY AND BAD STEEL

My records show as a general observation that rails rolled in August and September, when there is so much humidity in the air, have developed split heads in greater numbers than those rolled during the winter season. The moisture per cubic foot of air in August and September is often as high as 5 or 6 grains, while it may not be one-half of that amount during the winter weather. The use of refrigerated air in which the moisture was reduced to a low limit would be preferable in the Bessemer converters. Each ton of metal converted requires approximately about 0.6 ton of air to be blown through it, and with a large percentage of moisture it affects the physical properties of the metal by a greater inclusion of gases. The practice of many mills with direct metal to use a jet of steam to regulate the temperature of the blowing metal in lieu of scrap is decidedly objectionable and injurious to the resulting product.—*P. H. Dudley at Meeting of Society for Testing Metals.*

If the air were compressed to a pressure considerably higher than that required at the converter, then thoroughly aftercooled and drained and afterwards re-expanded to the blowing pressure, better results would seem to be assured. The apparatus and the power would, of course, cost something; but where do we get something for nothing?

CORRESPONDENCE.

FLOW OF AIR IN LONG TUBES

Editor of Compressed Air:

Mr. B. C. Batcheller, on "The Flow of Air in Long Tubes, with Especial Reference to Pneumatic Dispatch," in your issues from April to July, begins by developing a formula based on that of Prof. Unwin, who, he says was the first to take into account the variations of the density of air with variations in its pressure. The development of this formula is a matter of considerable mathematical complexity and leads to a structure of formula which, while probably correct, is somewhat long and complicated.

It is probable that Prof. Unwin was not the first to consider the effect of the change in density with change in pressure. A series of articles was published on this subject in the *American Machinist* in July, 1899, by J. E. Johnson, Jr., in which he developed a simple formula by integration from the fundamental theorem of fluid friction, that the loss of head varies as the square of the velocity, as the density, as the perimeter of the pipe and as the length of the same for short lengths. Expressing the air flow in weigh or cubic feet of free air and its volume and density at a given instant as a function of the pressure at that instant, he integrated the differential equation expressing this condition and obtained the formula—

$$P_1^2 - P_2^2 = \frac{KV^2 l}{d^5}$$

The value of K was determined from the results of the Mount Cenis experiments to be approximately .0006, when the diameter of the pipe was expressed in inches, its length in feet and the quantity of air flowing in cubic feet of free air per minute, P_1 and P_2, being initial and terminal absolute pressures in pounds per square inch. He then constructed diagrams whereby any ordinary problem in the flow of compressed air could be quickly and easily solved. Mr. Johnson also pointed out that after this work was done he had found substantially the same formula, without the numerical coëfficient, worked out in Church's "Mechanics of Engineering," published in 1890. As the work of Unwin, at a much later date than this, was based on the formula for the flow of water, whose density does not vary. it seems that Church, and not Unwin, should be the one to receive credit for first developing a correct and rational formula.

In a subsequent article Mr. Johnson outlined a method of conducting experiments to test the accuracy of this formula by determining the actual form of the curve expressing the relation between length of pipe and pressure. He also called attention to the fact that the natural gas pipe lines in the region around Pittsburg, in which the pressure fell through very wide ranges and the flow was received into gasometers, furnished ideal conditions for a large-scale experiment on this subject.

Several years later there appeared in the *American Machinist* an editorial note to the effect that such a test had actually been made and that with the proper coëfficient for density its results agreed perfectly, to all intents and purposes, with the formula and coëfficient worked out by Mr. Johnson.

The object in calling attention to these facts is not only to do justice to Prof. Church, but to point out the extreme simplicity of the formula given above which has, at the same time, the advantage of having been found by experiment to be absolutely correct.

JOHN J. SMITH.

FREE AIR CONTENT OF AIR RECEIVERS

Editor of Compressed Air:

In the article on "Air Brake Air Consumption," on page 4522 of your July issue, the capacity of a locomotive auxiliary reservoir is said to be about 3,900 cubic inches, and then it is stated that to charge one of these reservoirs to 110 pounds pressure requires about 29,250 cubic inches of free air.

I have tried to figure this out and I didn't come as near to it as I would like to. I did it this way: $110 \div 15 = 7\frac{1}{3}$ atmospheres. Then $3900 \times 7\frac{1}{3} = 28{,}600$. Will you kindly tell me where I am wrong?

THEODORE J. BUTTER.

[You are not really very far out of the way in your method. If the absolute pressure of free air is 14.7, then the absolute pressure of air at 110 pounds, gage, is all the gage pressure in addition to the free air valve, or $110 + 14.7$, or 124.7, and that will correctly represent the contents of the reservoir at 110 pounds, gage, and the number of atmospheres will be $124.7 \div 14.7 = 8.48$. It must be remembered, however, that when compression begins the reservoir already contains 1 atmosphere, so that the volume to be supplied will be only 7.48. Then $3900 \times 7.48 = 29{,}172$, which is somewhat less than the volume as given in the article to which our correspondent refers.]

TRADE PUBLICATIONS.

Transformer Testing for Central Station Managers. No. 8317. (Supersedes No. 8126). General Electric Company, Schenectady, N. Y. 42 pages, 5¼ x 3¼ inches.

Gas Engines for All Purposes. The Fairbanks Company, Broome and Lafayette streets, New York City, send us their finely printed Bulletins Nos. 5, 5A and 11, describing respectively the Improved Horizontal Engine, Horizontal Portable Engine and the Outdoor Engine.

Thermit Steel for Welding. Goldschmidt Thermit Company, 90 West Street, New York City; 24 pages, 6 x 9 inches; numerous illustrations. This pamphlet describes the now well-known Thermit process and gives many details as to its application to specific cases, particulars of apparatus employed, actual consumption of Thermit for each job, etc. Perhaps the most remarkable exhibit given is in the wide range of adaptability to repairs in place, such as welding stern frame of steamship, patching broken cylinder, welding steel truck frame. Instead of wasting material as in ordinary welding this process supplies material as needed.

Catalog No. 32, recently issued by the Chicago Pneumatic Tool Company, deals chiefly with the "Chicago Giant" rock drill and its usual appurtenances. The book of 96 pages, with numerous half-tones, is a beautiful specimen of modern book-making. The text is clear and fully explanatory of the drills, showing details of construction, the special system of lubrication, etc. The "Baby Giant" and "One Man" drill also is described and illustrated, and several pages are devoted to air compressors, drill steels and other related matters. The address of the company is Fischer Building, Chicago, or 95 Liberty street, New York.

MACHINERY READY TO SHIP WHEN PROMISED

"Don't ship our machinery yet; we are not ready for it; everyone is behind with their work."

This is the substance of more than one telegram to the Marine Iron Works of Chicago that recently came to our notice and brought out the following reply to our questions:

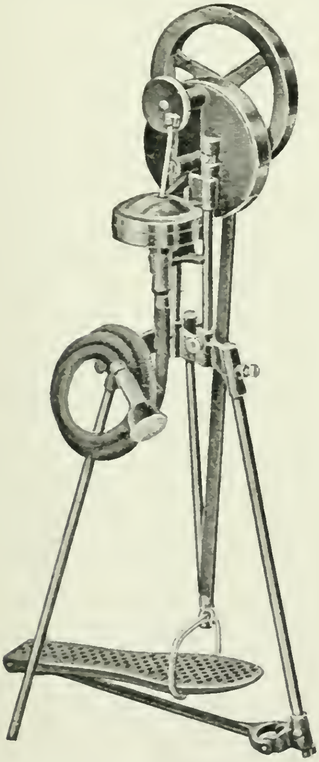
"Yes, we stick to our old text of 'lose an order rather than promise what we cannot perform' and no doubt we lose some business on that account, but I fail to see any sense or dollars in contracting for more than one can do. Buyers themselves are in part responsible for a practice that is becoming prevalent through insisting on a shipping date for special machinery from three to four weeks earlier than they need it, calculating that the builder will be that much behind his promise. As a consequence, many who make those promises are aware of the buyers' 'expectations,' and go him about four weeks better. We are up against just such a proposition right now where a concern who is making a special tool for us promised delivery in ninety days and we believed them, but that was five months ago and the tool not yet in sight. It takes long enough to build marine machinery without our adding or subtracting a single week, for it is all special work, built only to order and the experienced buyer is careful to anticipate his needs and allow ample time and thus be able to depend on a promise that is bona fide."—*Railway and Marine News, Seattle.*

In making rock excavations for building purposes in New York City and elsewhere, steam drills are frequently employed with temporary boiler installations. The Electric-Air drill not only renders the boiler absolutely useless for the purpose, but will do the work at a much lower cost without it, current being supplied by one of the big electric power companies.

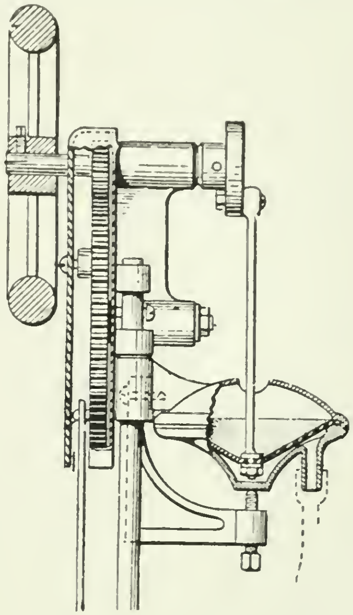
A very complete system of subways has been planned for the city of Chicago, more than $100,000 having been expended upon preliminary surveys, maps and plans, and when completed the rapid transit facilities of the city are expected to equal those of New York. It is understood that branch lines will extend to the west side, the Milwaukee avenue district, the north shore, Englewood, Hyde Park and Woodlawn. The company is known as the Chicago Subway Arcade and Traction Company, and a blanket franchise from the city is asked for.

PNEUMATIC MASSAGE MACHINE

The accompanying cuts, which we take from the *Scientific American* of recent date, show a wood massage apparatus recently patented by Mr. Carl Rosen, Pennoger Sanatorium, Kenosha, Wisconsin. This is not an air compressor but a pulsator pure and simple, and the operation can scarcely be called massage, as it does not suggest a rubbing or even a kneading operation. The machine is operated by foot power, the crank being speeded up by gear and pinion. The diaphragm is vibrated very rapidly in the cup which causes rapid alternations of blowing and sucking in the connected tube. There are no valves. The mouth of the hose is applied to any part of the surface of the body and moved about at the will of the operator.



PNEUMATIC MASSAGE MACHINE.



SECTION OF MASSAGE MACHINE.

HIGH TEMPERATURES

The fact that high temperatures are now daily obtained by means of the electric furnace, the oxy-actylene blowpipe and other artificial means causes an interest to be manifested in the actual temperature that is reached in melting refractory materials in the sun, whose temperature is the highest known.

Experiments with the optical pyrometer recently made are of interest as indicating the temperatures that are reached in certain operations and in the sun. These results are as follows:

Porcelain furnace	2498° F.
Glass furnace	2552° F.
Open-hearth steel	2795° F.
Melted platinum	3236° F.
Incandescent lamp	3272° F.
Arc lamp	7410° F.
The sun	13,712° F.

NOTES.

An Italian announces the invention of a perpetual motion machine operated by compressed air. We have no doubt that it will be a success wherever there is a perpetual supply of compressed air.

The Compressed Air and Vacuum Cleaning Company, St. Louis, Mo., has purchased a site for a new plant for the manufacture of house-cleaning apparatus operated by compressed air. The expenditure will be $200,000 and 300 men will be employed.

Mr. Frederick A. Waldron, Industrial Engineer, has opened an office at 37 Wall street, New York, with a branch office at 53 State street, Boston. Mr. Waldron, whose experience covers a period of twenty-nine years in manufacturing and engineering, will make a specialty of Profitable Factory Arrangement.

The Vacuum Air Compressor Company, of Wauseon, Ohio, was incorporated recently with a capital of $500,000 by E. L. Barber, W. F. Moughter, O. W. Baker, F. G. Jaquet and C. C. Brigham. The company will manufacture a new air compressor in a factory to be built in Wauseon.

A contemporary tells us that, according to the United States Geological Survey, there are over 1,200 mines under development in Oregon, giving employment to about 3,400 men; that's less than three men to a mine.

One of the puzzling questions to the manufacturer is the general tendency among works superintendents to fail in keeping a sufficient supply of extra parts on hand ready for an emergency. An extra valve or other part of an engine or a compressor, say, which experience has shown to be likely to be demanded, does not cost much, while a few days' delay may mean thousands of dollars.

There are now in Great Britain 119 engines of more than 500 horse-power each, the aggregate of these being 96,000 horse-power, or an average of 807. In Germany the number is 380; aggregate, 421,150; average, 1,108. In Belgium, 55; aggregate, 61,400; average, 1,116. Erhardt & Scumer have built one engine of 500 horse-power. This has four cylinders, 45x51 inches, running at 90 revolutions per minute.

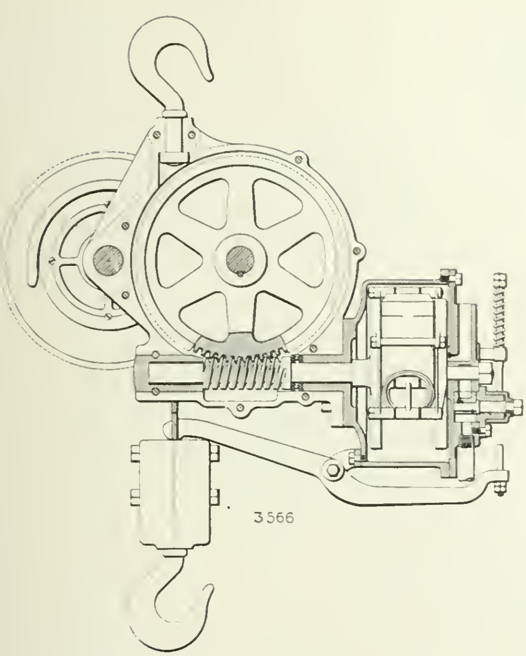
METAMORPHISM OF COAL.

At a small town called La Branca, in Sonora, Mexico, situated about sixty-five miles southeast of Torres on the Sonora branch of the Northern Pacific from Nogales to Guaymas, there is anthracite coal and natural coke. On looking over the outcrop, the only indication of coal is a gray clay, which on closer inspection proves to be ashes from burnt coal; below these ashes comes the natural coke, heavy in ash, although it will burn with a forced draft. Some of the veins are ten feet thick and extend down to nearly 100 feet; beneath the coke is anthracite coal of fine quality as far as analysis goes, but it slacks on exposure to the air. Apparently the coal measures were ruptured by a volcanic eruption, and the molten rock, on reaching the outcrop of the coal vein, burnt the coal to an ash where it had plenty of oxygen; when it did not have oxygen, it had the same effect as if placed in a coal-kiln. The pressure and heat changed the coal from bituminous to anthracite. Situated in this coal-field is the shaft of the old Tamorarra copper and silver mine, 500 feet deep in the eruptive rocks covering the coal measures. The copper and silver vein penetrates this eruptive, and on sinking the shaft, they encountered one of the coal seams, the coal being used in boilers for roasting, etc., in a chlorination plant.—*Mining and Scientific Press.*

THE IMPERIAL AIR MOTOR HOIST

The objectionable, and often prohibitory, features of the direct-acting air hoist are sufficiently familiar, and these are all conspicuous by their absence in the Imperial Air Motor Hoist here shown. It does not require a great height above the lift, and no more height for a high lift than for one not so high. The movement is perfectly controlled, both for hoisting and lowering, and the load is absolutely held at any point desired. There is no waste of air in filling long cylinders, the amount used at any time being only that required for the actual work.

The motor is a positive-action reversible air engine, with no dead centers and a practically uniform torque. It has no delicate valve mechanism requiring adjustment or liable to get out of order. It is wholly enclosed, dust-proof, splash oiling, with every bearing bushed and bathed in oil. The steel worm on the



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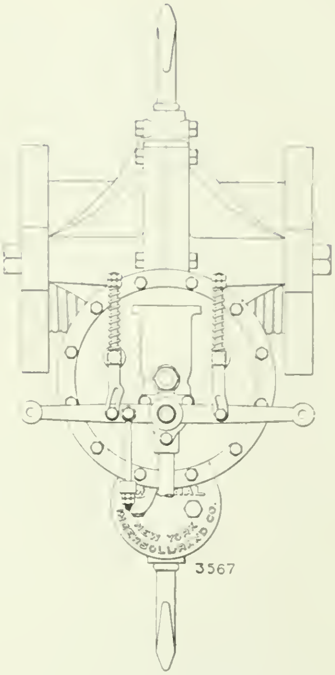

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motor shaft runs in an oil pocket, its thrust taken by a roller bearing, and meshes into a worm wheel of bronze, a pinion on the worm wheel shaft engaging the drum shaft gear. On the larger sizes of hoist there is an additional speed reduction; on all sizes the friction is the least possible, being minimized by the juxtaposition of the most suitable materials and the precise workmanship and finish of all working parts. The hoisting rope underruns a groove, which always permits an exact equalization of the two sides on the drum. The hook turns on ball bearings, the load may be turned in any direction without twisting the ropes and without its turning back. The action is steady and smooth, twelve of the hoists being used for hoisting flasks in one foundry. The hoist is made in five sizes, with capacities ranging from 1,000 to 10,000 pounds, using the ordinary air pressures. Built by the Ingersoll-Rand Company, 11 Broadway, New York City.

It is reported that the Chilean Government will soon begin the work on a railway running north and south, which will be of great importance in the development of mines, especially in the north of the republic.

LATEST U. S. PATENTS

JUNE 18.

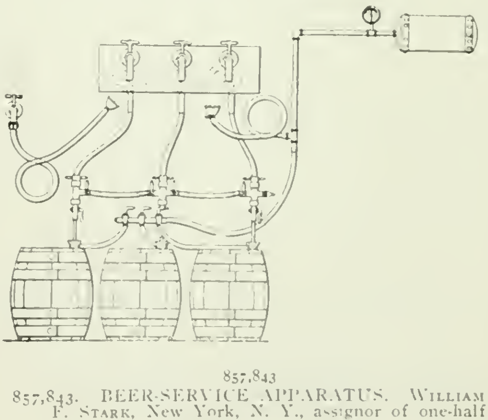
857,343. AUTOMATIC FLOW-REGULATOR FOR LIQUIDS AND GASES. JOHN H. GREGORY and WALTER W. JACKSON, Columbus, Ohio, and FREDERICK N. CONANT, Providence, R. I., assignors to Builders' Iron Foundry, Providence, R. I.

857,362. AUTOMATIC AIR-SIGNAL, AIR-BRAKE AND STEAM COUPLING. HERMAN C. PRIEBE, Blue Island, Ill.

857,477. PUMPING APPARATUS. GEORGE J. MURDOCK, Newark, N. J.

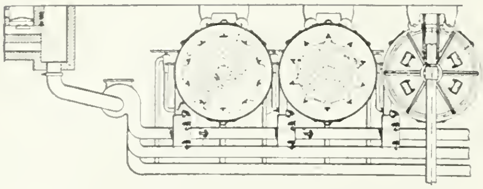
JUNE 25.

857,768. METHOD AND APPARATUS FOR RAISING LIQUIDS BY COMPRESSED AIR. ROBERT STIRLING, Surrey, England.



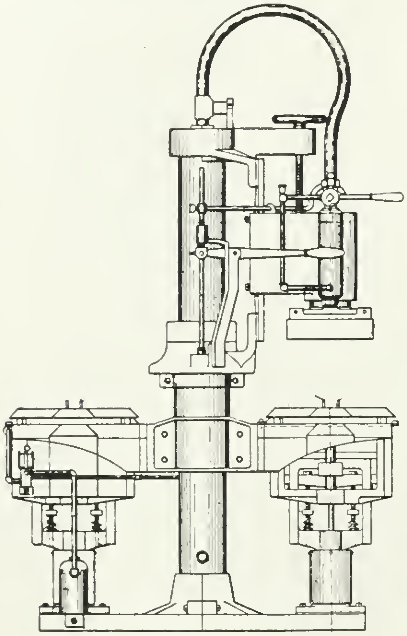
857,843

857,843. BEER-SERVICE APPARATUS. WILLIAM F. STARK, New York, N. Y., assignor of one-half to James English, New Haven, Conn.



857,945

857,954. PNEUMATIC MALTING AND PNEUMATIC DRYING APPARATUS. **Frederick H. C. Mey**, Buffalo, N. Y.



857,997

857,997. MOLDING-MACHINE. **Frederick W. Hall**, Camden, N. J., assignor of one-half to Howard M. Bougher and one-half to J. W. Paxson Company, Philadelphia, Pa.

858,039. AIR-PUMP. **Frank E. Ten Eyck**, Auburn, N. Y.

858,200. PNEUMATIC HAMMER. **John C. McCavney**, Superior, Wis.

Claim.—The hereindescribed *holding attachment* for pneumatic hammers comprising a cylindrical body for attachment to one end of the hammer barrel and having a partition provided with an air passage and ports leading therefrom to the interior of the hammer barrel and to the interior of said body, a piston in said body, a cap at the outer end of said body and a rod extending from said piston through an opening in said cap, for the purpose set forth.

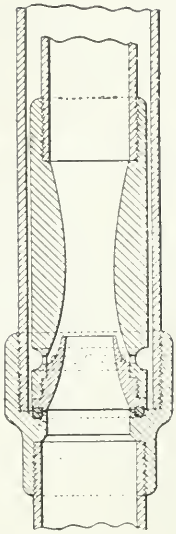
July 2.

858,398. FLUID-PRESSURE-OPERATED TOOL. **Charles H. Johnson**, Canton, Ohio, assignor to the Pittsburgh Pneumatic Company, Canton, Ohio.

858,442. GAS-SAVING OR PRESSURE-EQUALIZING VALVE. **James Cowie**, Chicago, Ill., assignor to National Gas Saving Company, Chicago.

858,467. AUTOMATIC DEVICE FOR STARTING MOTORS. **Walter J. Richards**, Milwaukee, Wis.

858,468. CONTROLLING APPARATUS. **Walter J. Richards**, Milwaukee, Wis.



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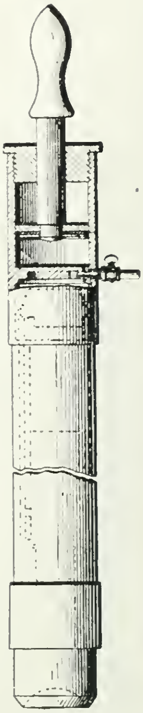

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858,469. FLUID PRESSURE SYSTEM. **Walter J. Richards**, Milwaukee, Wis.

858,470. FLUID PRESSURE SYSTEM. **Walter J. Richards**, Milwaukee, Wis.

858,471. CONTROLLING APPARATUS FOR PRESSURE SYSTEMS. **Walter J. Richards**, Milwaukee, Wis.

858,586. MEANS FOR SUPPLYING EXPLOSIVE VAPORS FOR OPERATING ROCK DRILLS. **Otho C. Duryea**, Brooklyn, N. Y., assignor to National Gas Drill Company, a Corporation of California.

858,588. WATER-LIFT. **George V. Ellis**, New York, assignor to the Ellis Company, New York.

858,592. BLOW-HEAD FOR GLASS-BLOWING MACHINES.

858,630. PNEUMATIC STACKER. **James B. Schumann**, Indianapolis.

858,635. REVERSIBLE MOTOR. **Edward J. St. Croix**, Seattle, Wash.

Claim.—In a fluid motor, a blade for the wheel thereof, said blade being approximately Z-shaped, thereby providing opposite recesses or impact portions on its opposite sides or faces.

858,640. METHOD OF BURNING FINELY-DIVIDED FUEL. **George S. Wells**, Chicago.

Claim.—The herein described method of burning finely divided fuel which consists in directing such fuel relatively radially into revolving air currents.

858,757. AMMONIA-COMPRESSOR. **Frank A. Rider**, Pittsburg, Pa.

858,793. RAILWAY-TRAFFIC-CONTROLLING APPARATUS. **Clyde J. Coleman**, Rockaway, N. J., assignor to the Hall Signal Company. (144 claims.)

858,911. PNEUMATIC CLEANER. **Armand Richter**, Garches, France.

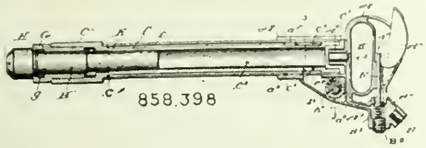
858,957. WATER-PRESSURE AIR-PUMP. **Alton E. Cobb**, Los Angeles, Cal.

858,964. PNEUMATIC MIRROR-BRACKET. GEORGE W. DAYTON and SHERIDAN P. HOTALING, King City, Cal.

859,021. MEANS AND APPARATUS FOR PRODUCING HIGH VACUUMS. FREDERICK SODDY, Glasgow, Scotland.

859,139. AIR-VALVE. IRA H. SPENCER, Hartford, Conn., assignor to The Oregon Power Company, Hartford, Conn.

859,170. VACUUM PUMP. JOSEPH J. MULLAW, Philadelphia.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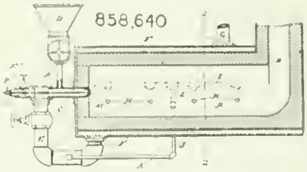
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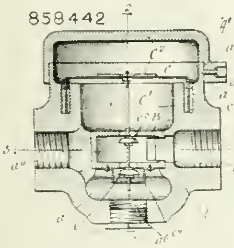
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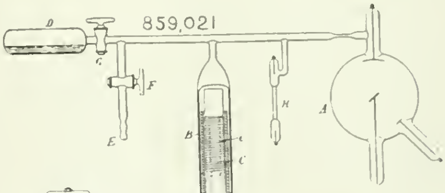
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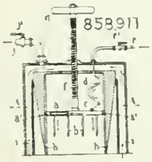
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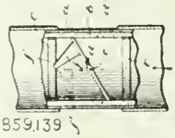
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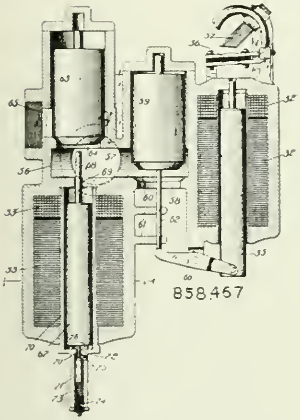
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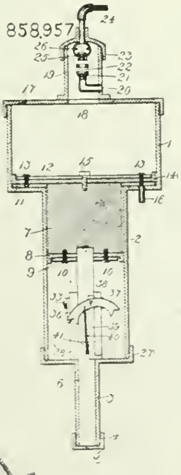
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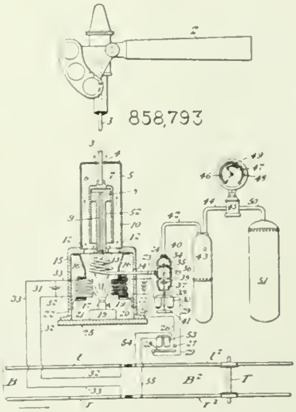
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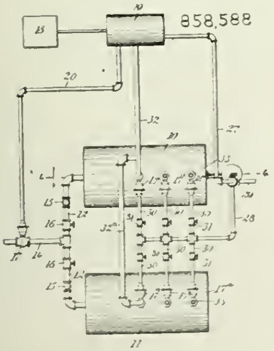
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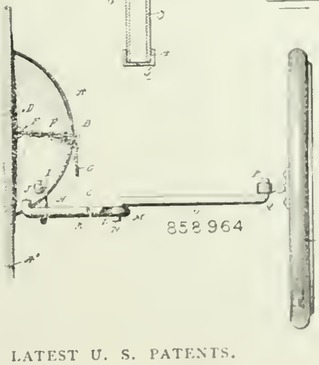
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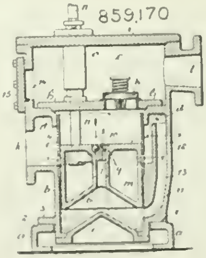
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LATEST U. S. PATENTS.

At present there is said to be more dynamite used in New York City than in any mining district in the United States. This is due primarily to the construction of the tunnels, of which about 38 miles are under construction, with 66 miles more projected. Since 1902 at least 2,000,000 tons of earth have been removed in underground work, in addition to about 3,500,000 tons removed in open-cut in connection with tunnel work. Many times this amount has been removed in excavating foundations for buildings not connected with the tunnel work.

Rock drills driven by air are necessary in mining operations and will remain so probably for years to come. For hard rock-boring there is no machine so universally used, and, consequently, as it is improbable that they can quickly be displaced by other classes of borers, every attention should be given to studying means of improving the present methods connected with their use. This is the more important inasmuch as in the utilization of power at the drill bit, the rock-drill is one of the most inefficient of common machines.

The pneumatic tube system in Philadelphia is being extended by the contractors, the Pneumatic Transit Company. At present the pneumatic system is in force from the main post office to the Bourse, the Pennsylvania and Philadelphia and Reading Railroad terminals, to Station S, Sixth street and Fairmount avenue, and Station O, Tenth street and Columbia avenue. The tubes to Station C, Nineteenth and Oxford streets, and Station J, Nineteenth and North streets, will be in operation by the last of August. The system will be extended to Station D, Eighteenth and Christian streets, and the Southwark station, Tenth street and Washington avenue, by November. A tube will also connect the main office with the new station in North Philadelphia.

Two unusual Chain Drives have recently been furnished by the Link Belt Company, both of them being of the Renold silent type. One installed to transmit 325 horse-power to refrigerating machinery in a brewery, consists of a pair of parallel chains on pulleys 14 feet apart, running at 1,100 feet per minute. The second drive runs a centrifugal pump from a horizontal turbine; its pulleys are 11 feet 7 inches apart, the speed is 1,755 feet per minute and the capacity of the chain is rated at 225 horse-power.

The last chapter is about to be written in the story of the Altoona cobbler who discovered the method of burning coal ashes that was to revolutionize the fuel industry. It is now declared that, allured by the promise of great wealth, he closed his cobbler shop and went gunning for big financial game. He is said to have been offered big prices for his patent and refused them. He failed to organize the stock company which he desired and is now reduced to the extremity of opening his cobbler shop again or starving.

A pumping engine of exceptional size has recently been ordered for the city of Nashville, Tenn. It will have a daily nominal capacity of 20,000,000 gallons of water, against a head of 390 feet, and will be operated by steam at a pressure of 160 pounds per square inch. The plunger speed is 240 feet per minute at 20 revolutions of the engine, the stroke being 6 feet. The duty guaranteed is 175,000,000 foot-pounds per 1,000 pounds of dry steam consumed by the engine and all its auxiliaries. The total horse-power required will be about 1,550. The engine is being built by the Allis-Chalmers Company.

Advertising has begun for bids for constructing Ashokan dam for the new water supply of the City of New York. This will be one of the most gigantic dams ever constructed, only the Assouan dam, in Egypt and Croton dam approaching it. The location is in the southern part of the Catskills. The dam will be 220 feet high, 196 feet thick at the base and 26 feet at the top and 1,000 feet long. The cost will be at least $10,000,000. There will be 2,055,000 cubic yards of earth excavated, 425,000 cubic yards of rock excavation, 7,055,000 yards of refilling and embanking, 210,000 yards of soil required for surface dressing, 1,100,000 barrels of Portland cement for the dam, 280,000 cubic yards of concrete masonry, 530,000 cubic yards of Cyclopean masonry, 64,000 yards of concrete blocks, 125,000 cubic yards of face dressing for concrete, 95,000 cubic yards of dry rubble paving, 929,000 pounds of cast and wrought iron and nearly a million feet of lumber.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

SEPTEMBER, 1907.

A MONTH'S OUTPUT OF AIR COMPRESSORS

By Frank Richards.

Compressed air in the last twenty years, and especially in the last decade, has had its work extended far beyond its original field of employment. The business of manufacturing air compressors was begun almost upon compulsion to supply the needs of the rock drill in mine and tunnel work. The readiness with which air compressors have become procurable, the persistent aim of the manufacturers to adapt the machines to the varied requirements of different lines of service as they have developed, the attention which has been given to the promotion of the possible economies in the development of power and in its application to this specific purpose, the perfect reliability and automatism which have become so characteristic of the best makes, have made their services highly desirable in many, if not most, lines of industry, and accordingly to-day the rock drill is only one of many large and constant users of compressed air, and the air compressor finds employment in connection with every line of human activity.

While the rock drill was thus the first employer of the air compressor, the latter has now fully reciprocated the service, and by its ready and almost universal presence has made more and more work for the rock drill and its lineal descendants. The rock drill has developed into the pneumatic tool, and this has multiplied and differentiated until the relationship of some of the successors to the original percussion drill can no longer be traced, and the work they do is as far as possible from the drilling of rock.

I have before me a detailed list of the output of air compressors by the Ingersoll-Rand Company for a recent calendar month; that is, from the 16th of one month to the 15th of the next, inclusive, and from it we may gather a number of items as to the extent and diversity of the employment of compressed air at the present time. This is not an altogether typical month's business, as several types of compressors which are generally represented in a month's list of sales by this company do not figure in this, and the shipments also have not the usual reach of the foreign trade. Whether the total for the month is larger or smaller than the average I do not know; I merely have happened to catch on to this particular list and have got what I could out of it.

The number of compressors in the list is 173 and the aggregate horse-power is 16,000, making 92 the average horse-power for the entire list, so that these are not little machines which would be of no account except for the number of them.

The total free air per minute capacity of these machines is 97,000 cubic feet, this volume being equal to that of a cube with a side of 46 feet. Nothing can be deduced from this as to the economy of power in compression, as the air is delivered at various pressures, the compressors also working at different altitudes and under various other conditions affecting the ultimate economy.

If any one is disposed to think that the building of air compressors is a simple business, comparable, for instance, with the building of steam engines, attention is called to the fact that there are 85 different types, styles, sizes or combinations of details included in this list of 173 machines. Taking the list all through the average is only about two machines which duplicate. The month preceding or the month following would each show a number of still different machines, and so on throughout the year, and the number of different machines which may be called for is almost endless. It is, in fact, actually endless, for new machines are coming along continually, each having some honest claim for preference over previous designs, and new requirements arise calling for other new arrangements.

The great variety of the machines represented in the list is not due largely either to caprice or to complete error of judgment. There is a reason, not always of sufficient weight to be authoritatively conclusive, but still a definite and tangible reason, to be advanced for each selection. For instance, if we divide the list as below the reasons or the prevailing considerations will begin to appear.

STEAM-DRIVEN.	
Single steam and single air cylinders	53
Single steam and compound air cylinders	4
Duplex steam and duplex air cylinders	5
Duplex steam and compound air cylinders	17
Compound steam and comp'd air cylinders	18
POWER-DRIVEN.	
Electric drive and single air cylinders	3
Electric drive and duplex air cylinders	13
Belt or gear and single air cylinders	24
Belt or gear and duplex air cylinders	12
Belt or gear and compound air cylinders	4
Belt or gear and three-stage air cylinders	20
	173

The reason, or, rather, the explanation, for the first and largest item of this list, that of the 53 compressors with single steam and single air cylinders, 54 per cent. of all the steam driven machines, is perhaps the least defensible of all. These machines represent to a certain extent the survival of the unfittest. The earlier air compressors were first of all cheap and simple; they ignored almost completely the evidently possible economies of operation. Both in the use of the steam for the development of the power and in its application to the work of compression they were wasteful almost to the limit of the possibilities in that direction, and their wide employment retroacted to the discrediting of compressed air for all purposes. Great numbers of these compressors survive in active service, and, except for the wasting of the fuel, they give such satisfaction and entail so little other expense in supervision and maintenance that many who are accustomed to them will have no others. There are many compressors in this lot to which these remarks only partially apply, they being machines of small size and therefore more or less justified in ignoring the possible economies which in their case would be too minute for practical consideration.

The next largest number in the list of steam-driven machines, the 18 with compound steam and compound air cylinders, these being about 18½ per cent. as compared with the 54 per cent. above of the total of steam-driven compressors, represent the machines which realize the highest practicable economies in operation. It is understood that condensers for the steam and intercoolers for the air are employed, and then it is a common thing for compressors of this class to show a saving of one-half of the fuel used as compared with the consumption of the class first mentioned, so that when in continuous operation they may be said to pay for themselves in a short time, some of them, as the records will show, in a single year.

It must not be assumed that the entire economies of this class are available for all steam-driven compressors, or that all compressors should be built with both compound steam and compound air cylinders, although the number of these should be largely increased. It is a rather curious thing that in the month's list of compressors here under consideration there is not a single example of the class of compressors, built by the same company, most numerously employed in connection with the New York subaqueous tunnel work. These would appear in the list as "compound steam and duplex air," the two air cylinders of each machine being both for single-stage compression, and for the very sufficient reason that the air pressure required does not usually exceed 30 pounds.

Next in numbers on the list are the seventeen "duplex steam and compound air." The four "single steam and compound air" really are the same as to economy of operation, the former machines being double and the latter single. Many compressors are so small as to make the compounding of the steam end hardly worth while, and for that reason we may excuse the four single machines, but we may infer that the duplex machines were large enough to make the compounding of the steam ends, with of course condensers and if possible high-pressure steam, the only proper thing, but customers and users are not yet all educated up to this.

The proportion of power-driven machines, as distinguished from direct-steam machines, continually increases, and for this the electric drive is a sufficient explanation. We may assume that more than one-half of the belt or gear driven machines in the list are really motor driven, in addition to those listed as "electric," the latter having the motor provided as an integral part of the machine.

The twenty three-stage machines in the power list represent the highest possible economy as to the compression of the air impressed for special service; the other power-driven machines generally represent the smaller compressors of the list, but still it does not look well to see only four compound air ends in the lot. It does not represent the approved and strenuously advocated practice of the builders, but rather the peculiar over-weighing of first cost by the purchasers. They may save a little in the machinery bill but must pay it out elsewhere and without end.

Running down the list and noting the purchasers, a rather astonishing variety of industries is indicated in these sales of a single month. No attempt is made at arrangement: Talc company, stone quarry, building contractor, car works, ice company, plate-glass company, coke company, railroad companies, coal mines, boiler works, foundries, stone yards, carbide company, prospecting, iron mines, structural iron works, machine tool works, motor car works, city corporation, fuel company, sand company, carpet cleaning, rapid transit company, gas engine works, dredging company, kodak company, meat packing company, lumber company, steel foundry, malleable iron foundry, scale works, oil company, dye works, salt company, rubber company, sheet and tube works, lead and smelting company, gaslight company, shipbuilding company, water works, pneumatic dispatch, technical school, brewing company, wrecking company, silk mill, electric light company, glue works, pump works, cement works, water company, park company, cold storage, distillery.

In the lines of quarrying and mining and also in railroading, which would include both the driving of tunnels and shop and yard work, there are of course several entries, and more than one under most of the others mentioned, while many give no indication of the line of business, but the variety of employment would seem to be sufficiently indicated.

These compressors will be distributed over thirty of the States of the Union, as follows: New York, 39; Pennsylvania, 37; Ohio, 12; New Jersey, 9; Massachusetts, 8; Illinois, 5; Maryland, 4; Virginia, 4; Alabama, 3; Georgia, 3; Indiana, 3; Michigan, 3; Montana, 3; Tennessee, 3; Florida, 2; Kansas, 2; Kentucky, 2; Minnesota, 2; North Carolina, 2; New Mexico, 2, and Arizona, Arkansas, Idaho, Iowa, Rhode Island, Texas, Utah and Vermont, 1 each. The foreign business of the company, usually reaching at least half a dozen countries per month, is in this list represented only by four compressors to Mexico. The number of compressors here credited to New York is misleading, many having been sold in New York City to the resident representatives of companies doing business in distant States. Pennsylvania is undoubtedly by far the bigger customer.

All lines of business in all parts of America and in all foreign lands are thus interested in and more or less dependent upon the air compressor, and the demand for its constant services was never more active and growing than to-day. The growth is much more rapid than that of population, the per capita "consumption" of compressed air being constantly on the increase, and the rate of consumption of compressed air may be taken as well as anything which has been proposed as a measure of our progress in civilization.

WIND PRESSURES

Experiments have been made at the National Physical Laboratory, London, which bring out a new and practically very valuable fact—namely, that pressure is not the same on large surfaces as on small experimental models. If, for example, a given wind velocity is brought to bear on a square foot of surface it will be 18 per cent. less per square foot than if it were directed on 100 square feet of surface. It was demonstrated, too, that this relation is constant for flat forms, however complicated. A builder or engineer who knows that a structure may be exposed to a wind of eighty miles per hour and that the pressure per square foot as determined by model is, say, x pounds, should allow for his larger construction 20 per cent. extra. The reason for this seems to be the more thoroughly reduced pressure on the lee side of a larger area.

Many years ago the Royal Meteorological Society arranged an exhibition of apparatus for measuring wind velocities. It was an extraordinary assortment of instruments, of which one only, and that a purely empirical design, seemed to achieve the object—the well-known Robinson's hemispherical cups, invented by a clergyman. So everybody made up his mind that the thing could not be done scientifically. Straightway Mr. Dines, F.R.M.S., went and did it.

The work of piercing the tunnel through the Tauern Mountains in the Tyrol, a few miles south of Gastein, has just been completed. The tunnel is five and a half miles long and the work has taken six years. It is the last important work in the series of Alpine railways. The new tunnel alone shortens the distance between Salzburg and Trieste 110 miles.

HIGH PRESSURE GAS DISTRIBUTION

At a recent meeting of the Institute of Civil Engineers, London, an interesting discussion occurred upon the above topic.

Mr. A. J. Martin drew attention to the fact that, notwithstanding high distributing pressure, the leakage, comprised in the unaccounted for gas, continued low. He had learned by inquiry that at Aurora, Ill., where a distributing pressure of 15 pounds per square inch had been used—it was being increased to 50 pounds—there had been no trouble from excessive leakage. With higher pressures of distribution it seemed likely that small gasworks would disappear, and the supply be taken over by the larger works some distance away, which had better facilities for obtaining cheap coal. Regarding a gas distributing system as a power distributor from a central source, he would go farther than Mr. Carpenter, and say that it was cheaper than an electricity distributing system. The weight of copper required to convey a certain power electrically was greater than the weight of the steel mains required to convey the same power the same distance by gas at high pressure. The relative prices of copper and steel made the comparison very favorable to gas. Further, it must be remembered that the cost of the copper was doubled or trebled by the cost of insulation. The loss of current in transmission was 10 to 20 per cent. against 2 to 3 per cent. loss with gas; 4-inch gas pipes at 60 pounds pressure would serve to convey gas equivalent to the 4000 kilowatts which the London County Council's electricity supply scheme had proposed to send on the average from Greenwich to each of twenty-nine substations. The cost of the cables and ducts had been estimated at £666,000; the 4-inch gas pipes would cost only £43,000, and would transmit the same power. The cost of the coal used by the London Electricity Supply Companies was often greater than the cost of the equivalent quantity of coal gas—at the price now charged by the South Metropolitan Gas Company. The gas companies should be freed from all restrictions, so that they might have a free hand to supply that gas which they found most suitable for their customers.

Mr. W. J. Dibdin, F. I. C., thought the use of gas at high pressure a great advantage for heating purposes in laboratories.

Mr. T. S. Lacey, of the Gas Light and Coke Company, said that from the first it had been necessary to pump gas from Beckton to London, as the holder pressure was quite inadequate when the distance to be traversed was so great (10 to 12 miles). At the stations in London there were pumps for taking the gas from, or putting it into, the 48-inch high-pressure mains, according to the immediate requirements. A higher distributing pressure would be a great advantage to users of the incandescent burner.

Mr. A. Auden said that he had found gas at high pressure very good for lighting purposes in a factory, but troublesome for keeping type-metal melted, and he had eventually put in a low-pressure service again for the latter purpose.

Mr. W. King reported that he had found it necessary to introduce high-pressure distribution at Liverpool as early as 1878, and by degrees they reached a pressure of 40 to 45 inches. They had used Beale's exhausters for pumping. For the pipes he used entirely bored and turned joints, as introduced in Liverpool in 1826 by his father.

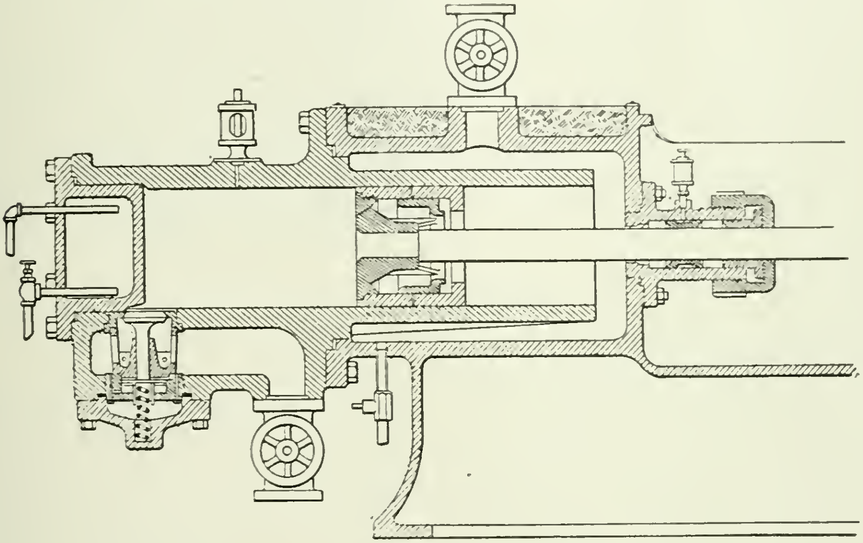
Mr. Dolby having mentioned an instance of an explosion due to gas escaping from a water-slide pendant in a consumer's house, when it was supposed that the distributing pressure had been increased in order to fill balloons with gas, Sir George Livesey said that the South Metropolitan Gas Company was altering all water-slide fittings in its district in order to make them safe. Pressure could not be increased to any considerable extent while these fittings remained in use. Then, again, the meters needed some adaptation for use with the higher pressures. It was essential, however, that the consumer should get a higher pressure. Strangely enough, the time at which the South Metropolitan Gas Company found it most difficult to maintain adequate pressure in the mains was between 11 and 12 o'clock on Sunday mornings, when so many dinners were being cooked.

Mr. Carpenter said that Sir George Livesey had already answered for him some of the points raised in the discussion. The amount of gas sent out by his company was at a maximum equivalent to about 500,000 horsepower per hour if used in gas engines. The chicken incubator was an illustration of the practicability of maintaining a uniform temperature by regulation of a gas flame.

RIDER AMMONIA COMPRESSOR

This compressor is of interest in itself for its novelty of design, and also as calling attention to the difference in conditions when compressing ammonia gas for refrigeration purposes and when compressing air to be used, as it mostly is, as a power transmitter. In either case the same theoretical condition prevails: it is desirable to fill the cylinder as full as possible at the beginning of the compression stroke, and the fluid to be compressed should be at as low a temperature as possible. It happens, however, that while air comes to the compressor at about the temperature of the atmosphere ammonia, after absorbing heat generously in the act of re-evaporation, still returns to the compressor at a temperature often about zero. The absurdity, then, of water jacketing the cylinder which is to receive this cold ammonia is apparent. The water in such a case of course acts as a heater rather than as a cooler, and by increasing the ammonia volume adds to the power cost of the compression.

The cylinder here shown in section is surrounded by the cold ammonia, and each charge enters the cylinder without coming in contact with any other than the coldest surfaces. The gas passes through the piston by a passage equal to about 25 per cent. of the cylinder area and is compressed in the left hand end. There is no heating of the gas to a temperature that would make a water jacket effective until near the end of the stroke, so that only the cylinder head has such a jacket or is made hollow so that a considerable body of water is constantly circulating in it. The inlet valve in the piston opens autward so that it is not possible for it to get into the cylinder; it is without springs but is cushioned by the gas to prevent shock.



COMPRESSING CYLINDER OF RIDER AMMONIA COMPRESSOR.

The discharge valve is located, as seen, in the bottom of the cylinder to allow the escape of any liquid which might enter during the dry compression process, or if the machine should be used as a wet compressor this drainage valve prevents the likelihood of liquid ammonia re-evaporating in the clearance spaces. Also any liquid which may come over in the suction is discharged ahead of the gas. It will be seen that the piston rod stuffing box is exposed to little pressure and therefore is easily kept tight. The rod and the cylinder are oiled in the usual way with automatic sight feed lubricators. The stroke is long and the piston travels close, so that the clearance is very small, an important thing in this service. The steam ends of these compressors are of the Corliss type and give high efficiency.

This compressor has been recently patented by Mr. Frank A. Rider, Pittsburgh, Pa.

A large gas engine rated at 1,650 horsepower at 107 r. p. m. when using furnace gas at 80 B. t. u. has recently been completed by the Wm. Tod. Co., for the Ohio works of the Carnegie Steel Co.

THE FOG SIGNAL PROBLEM

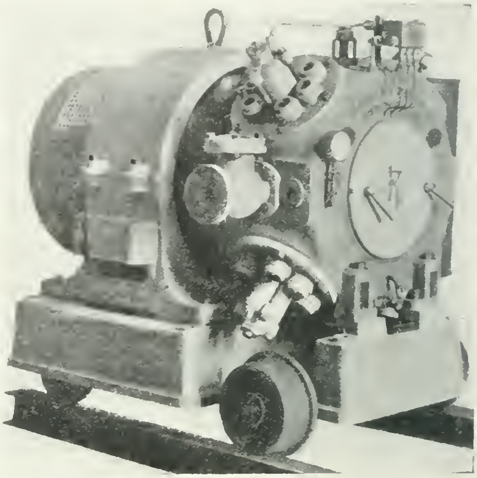
Every lighthouse of any importance on our coast has some sound-producing apparatus for a fog signal, a bell, a whistle, a Daball trumpet, or a steam syren. The sound produced, with its periods of intermission, serve to distinguish each fog signal from any other sound in its neighborhood. Fog signals are a most unsatisfactory device especially on account of the uncertainty as to the audibility of them under different conditions of sea and weather, and also the difficulty of determining the direction of their location.

The list of cautions to mariners published by the Lighthouse Board are almost funny in the suggestions of uncertainty as to fog signals. A mariner should not assume that he is out of hearing of the fog signal because he doesn't hear it, nor because he hears it faintly assume that he is far from it, nor assume that he is close to it because he hears it plainly, nor assume that he is in a given place because he hears the sound the same as he did on a former occasion when there. He must not assume when he no longer hears a signal that it has ceased to sound. He should not expect these aberrations of audibility of one signal to be the same with any other. He should not expect to hear a fog signal well when there is a swiftly flowing stream between him and it or when wind and tide are in opposite directions. These are only a few of the points mentioned.

The *Scientific American* states the problem of the fog signal as follows:

"To invent or discover a sound-producing apparatus, no more complicated or expensive, or but slightly more so, than those in use, which will be heard uniformly at uniform distances, exception being made in favor of sounds swept away by a heavy wind; or to invent or discover a means of improving present fog signals, as a resonator or reflector, which will so amplify, direct, reflect, or otherwise project the sound that it will not be subject to the aberrations above described, saving that caused by a heavy wind. There is a wide market ready for the invention which solves this problem.

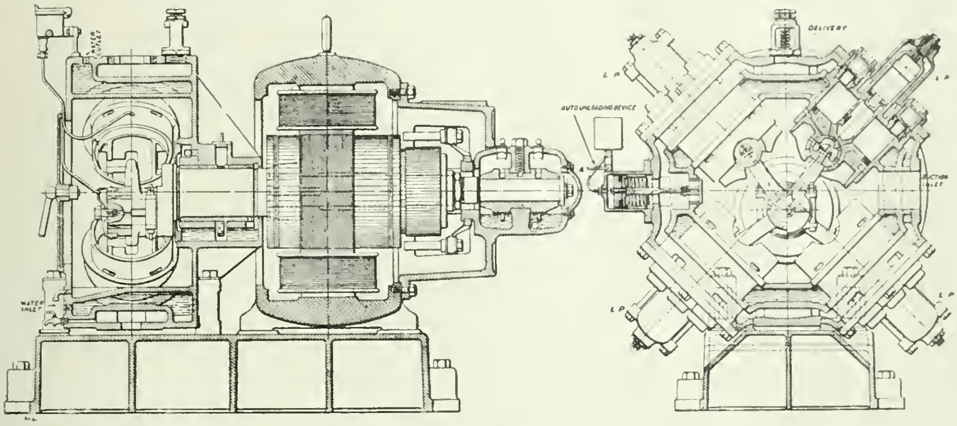
"The problem has another side: It is not enough to warn the mariner of a danger, or point out the course, by a sound: it is necessary to provide him with a means of finding the direction of the sound. Can you locate a cricket? In a fog the sound seems to come from all directions, unless it is right on top of the vessel, and then the inevitable collision results. The very fact that in spite of warning apparatus of the greatest power collisions frequently occur, shows that some method is needed to definitely locate a sound.



EFFICIENCY TESTS OF REAVELL AIR COMPRESSOR

The illustrations herewith and the following data obtained from actual tests we adapt from a recent issue of *Engineering*, London. The compressor, it will be seen, is portable and direct driven by an electric motor with four radial single-acting air cylinders, whose pistons are actuated from a single crank on the motor driven shaft. The compressor was built for driving reciprocating coal cutters in an English coal mine.

The interesting debate on air compressors which took place at the Engineering Conference turned largely upon the question of the relative efficiencies of turbo and reciprocating machines. The difficulty of making exact tests, and the difference of opinion which exists as to the proper way in which efficiency should be measured, account for much of the confusion by which the subject is surrounded. If the heat generated during compression could be continuously extracted, so that compression was isothermal, the work done would be a minimum, and the efficiency, consequently, the highest possible. Isothermal compression is quite impossible of realization, though the ideal forms a convenient basis for comparison. On the other hand, one may assume no heat abstracted, and compute efficiency, therefore, on the basis of an adiabatic compression. This is in a sense fairer to the machine, but not so good a guide to the purchaser, particularly if he wants to use his air cold. A third method is that used by Professor Rateau, by which, in the absence of water cooling, the efficiency is deduced from the temperature rise of the air in passing through the machine.



REAVELL AIR COMPRESSOR.

Rated size of machine............	230 cub. ft. of free air per minute.
Diameter of cylinders............	10 in.
Length of stroke (effective)........	4¾ "
Average revolutions per minute...	325
" delivery pressure.........	70 lb. per sq. in.
" volts	460
" amperes	68
" electrical horse-power....	42
Motor efficiency.......	88 per cent.
Brake horse-power................	36 9
Capacity of air-receiver....	93 cub. ft.
Revolutions taken to fill receiver (Full pressure being maintained all the time in auxiliary receiver.)	595
Mean temperature of air in the receiver	100 deg. Fahr
Mean temperature of air in suction	65 " "
" " at delivery of compressor	160 " "
Equivalent volume of free air delivered into receiver per minute..	237 cub. ft.
Equivalent volume of free air reduced to 65 deg. Fahr............	222 "
Volume swept by pistons of compressor......	255 "
Actual mean effective pressure from diagram at 65 deg. Fahr. inlet and 160 deg. Fahr. outlet temperature	30 lb.
Theoretical power required from this diagram.....................	29.1 horse-power
Apparent volumetric efficiency based on time taken to fill reservoir against full pressure $\frac{237 \times 100}{255}$	93 per cent.
Real volumetric efficiency corrected to atmospheric temperature $\frac{222 \times 100}{255}$	87 "
Over-all efficiency $\frac{29.1 \times 100}{36.9}$	79 "
Mechanical efficiency by deduction..........	91 "
Isothermal mean effective pressure	25.74 lb.
Theoretical power assuming isothermal compression	24 horse-power
Thermal efficiency $\frac{24 \times 100}{29.1}$	82½ per cent.
Absolute efficiency from actual power on shaft to isothermal diagram.................	65.2 "

From the above it will be seen that the efficiency on the basis of isothermal compression is over 65 per cent., while the efficiency calculated after Professor Rateau's method is 79 per cent. This latter is termed by Messrs. Reavell the "actual efficiency," and takes into account leakage and clearance losses. This is undoubtedly good for a machine dealing with only 230 cubic feet of air per minute.

RECIPROCATING AIR-COMPRESSORS.

By W. Reavell.

I propose in this note to deal with the features which are necessary to obtain high efficiency in a reciprocating air-compressor. With the exception of low-pressure unjacketed machines, such as blowing-engines, the observations are applicable to all compressors within the limits of pressure ordinarily met with.

The losses to which an air-compressor is subjected may be divided into three heads, namely, thermal, mechanical and volumetric, and I propose to examine these in their order.

Thermal Losses.—In an ideal compressor, all the heat generated by doing work on the air in compression would be abstracted and the compression curve would be isothermal, the enclosed area of the indicator diagram representing the work done being then the smallest possible. In order to approach this ideal in practice, water-injection, water-jacketing, and intercooling may be used.

I have referred to water-injection first as it was one of the earliest methods adopted, but it is now rarely met with in modern practice. To be most efficacious the water should be introduced in the form of a fine spray during compression, and this involves the use of a pump. Moreover, if the quantity used is limited to that required to be converted into vapor, it is clear that the air could not be cooled below 212 deg. F., while if a pump is avoided and the water added more freely during the suction-stroke, it becomes a source of danger in a quickly reciprocating machine, and requires provision made for its removal after compression.

The efficiency of water-jackets (neglecting variations in temperature of jacket-water, and assuming a constant supply) depends upon the thickness of the cylinder-walls, the ratio of cylinder cooling surface to piston area, and the piston speed. Hence a compressor having one large cylinder will not be so efficient as one having a number of smaller cylinders, assuming the piston speed to be the same.

For the same reason a single-acting machine will have a higher thermal efficiency than a double-acting compressor, as each alternate stroke is an idle stroke, so that the mean temperature of the cylinder walls will be obviously less and the heat will be abstracted better.

Intercoolers.—When compression takes place in more than one stage, an intercooler should be placed between the cylinders, and should be proportioned so as to reduce the air as nearly as possible to the temperature it had on first entering the machine. The result is naturally to reduce its volume considerably and to reduce the power required during the next stage of compression.

Although from the point of view of volumetric efficiency it is desirable, it is mainly for thermal reasons that intercoolers are used, and, other things being equal, the larger the compressor, the lower the pressure at which it becomes economical to compress in two or more stages instead of one.

Volumetric Losses.—The volumetric efficiency of a machine is the ratio of the weight of delivered air to that represented by the piston displacement, and the losses which impair this efficiency are due to clearance, valve-resistance and leakage.

The greater the clearance between piston and cylinder head at the end of the stroke, and the greater the cubic contents of the valve passages, the greater will be the ratio between the piston displacement and the air actually delivered per stroke; and on account of the necessity of making provision for wear this loss is greater in double-acting than in single-acting compressors.

Valve Resistance.—With spring-loaded suction valves the air pressure in the cylinder during the suction stroke is less than that of the atmosphere, owing to the resistance of the springs, and hence the importance of using mechanically-operated suction valves which give a free admission of air during the suction stroke. With spring-loaded delivery valves, there will be a slight increase of pressure in the cylinder as compared with that in the delivery pipe, depending on the design of the delivery valve and the strength of the spring. This excess pressure has usually no appreciable effect on the volumetric losses, but it does, together with the attenuation losses on the suction side, increase the area of the indicator-diagram and increase the power required to drive the machine. Volumetric loss from leakage is traceable to piston rings, stuffing boxes, and defective valves.

It is undoubtedly equally as important in air-compressors as in steam engines to pay careful attention to the design of piston rings; and if all compressors were always tested for volumetric efficiency many a machine which was credited with an excellent performance, judged from the indicator card, would be found to owe the resemblance of its compression curve to the isothermal curve more to leakage of air past piston rings than to excellence of water-jacketing. Experiments I have carried out showed that, in small compressors, a considerable improvement in efficiency was obtained by fitting piston rings of the Willans type instead of "sprung on" Ramsbottom rings.

Mechanical Losses.—The mechanical efficiency of a compressor is represented by the ratio of the work done, as shown by the indicator-diagram in the compressor cylinder, to the power actually applied at the crank shaft to operate the compressor. These losses are of course frictional, and are due to piston rings and stuffing boxes, slippers, guides, bearings, and questions of alignment when more than two bearings are used.

Valves.—I have already referred to the advantages of mechanically-operated as compared with spring-loaded valves, and to give the large opening required for admitting air to the cylinder without attenuation, the mechanically-operated suction valve is preferable. For delivery valves the mechanically-operated type is not as frequently met with, because of the difficulty of readily adjusting it for different delivery pressures.

Governing.—An important matter to consider in connection with air-compressors is the varying of the power exerted, in accordance with the demands for air, and so as to maintain the air pressure as constant as possible. When the compressor is steam-driven, the speed of the machine can be varied automatically by a valve operated by slight variations in the air pressure; but when the compressor is driven at a constant speed other means are necessary. If the machine is belt-driven an automatic appliance should be fitted, operated by fluctuations in pressure to move the belt from fast to loose pulley.

When electrically driven, the machine can be fitted with an automatic switch to stop and start it in accordance with the changes in pressure due to variation of demand. It is essential with these two methods to have a very large reservoir compared with the capacity of the machine, and hence many machines are fitted with an unloading device which enables the machine to run nominally without load. These operate by holding the suction-valve open during the delivery stroke, or some similar method.

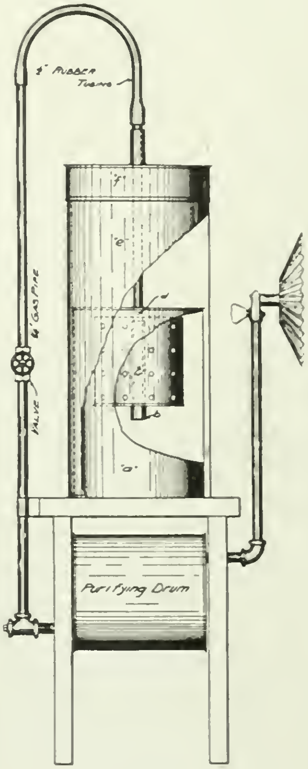
This method, which may be termed the "all or nothing" method, is not very satisfactory, especially for electric driving, as it gives such fluctuating loads to the motor, and methods of varying the volume will undoubtedly be perfected by compressor designers to meet this defect.

The motor used by M. Santos Dumont in his recent more or less successful attempt to fly with an aeroplane weighed slightly more than two pounds per horsepower.

The total excavations from the Panama canal during June, according to a report from Chief Engineer Lieutenant-Colonel Goethals, was 780,957 yards

A PORTABLE ACETYLENE MINE LAMP

The sketch herewith, which we reproduce from the *Mining and Scientific Press,* shows a lamp in common use in Mexican mines. It is a home-made affair, but is said to be quite satisfactory, and on account of the cost of other illuminants acetylene lamps are quite numerous. This type of lamp was used continuously in one Mexican mine while air connections were being made.



ACETYLENE LAMP.

Acetylene requiring less oxygen than other illuminants, it was found that faces could be worked where an ordinary lamp or candle would not burn. In large stopes it also proved satisfactory, since the amount of light furnished by one lamp was greater than that of a number of candles or a torch and, the lamp being portable, it could be moved from place to place, wherever light was most needed. The lamp can be cheaply constructed; any tinsmith or ordinary mechanic will have little difficulty in making one out of ordinary galvanized iron and a few pieces of pipe.

The method of charging the lamp is as follows: The rubber tubing is first disconnected and the cover *f* is removed; the gas-drum *a* containing the carbide-drum is now removed and the cap *b* unscrewed. The carbide-drum can now be slipped off and is filled with about 2 pounds calcium carbide, which should be in rather large lumps. The carbide-drum is now put back into place and the water cylinder *e* is about half-filled with water; now carefully lower the gas-drum into the water, being careful not to allow the carbide to touch the water until the cover *f* is replaced and the rubber tubing is connected. The small valve in the pipe leading to the purifying-drum may now be opened, allowing the air to escape through the drum and gas-jet. As soon as the air has all escaped the drum containing the carbide will come in contact with the water and acetylene gas will be generated. This gas enters the gas-drum *a* and finds its way into the pipe by way of the small hole *d*, and passes into the purifying-drum which is packed with cotton-waste, which will take up any small particles of dust. From the drum the gas passes into the pipe fitted with a Stewart patent gas-tip.

The lamp is self-regulating, for as soon as more gas than can be immediately used is generated, the pressure of gas will raise the gas-drum *a* and, the carbide-drum, being attached to the other drum, will be lifted out of the water and no more gas will be generated. As the gas is used up, the gas-drum with the carbide-drum will settle down into the water again and more gas will be generated. The lamp being self-regulating, little attention need be paid to it after charging and starting.

HEAVY FUEL OILS

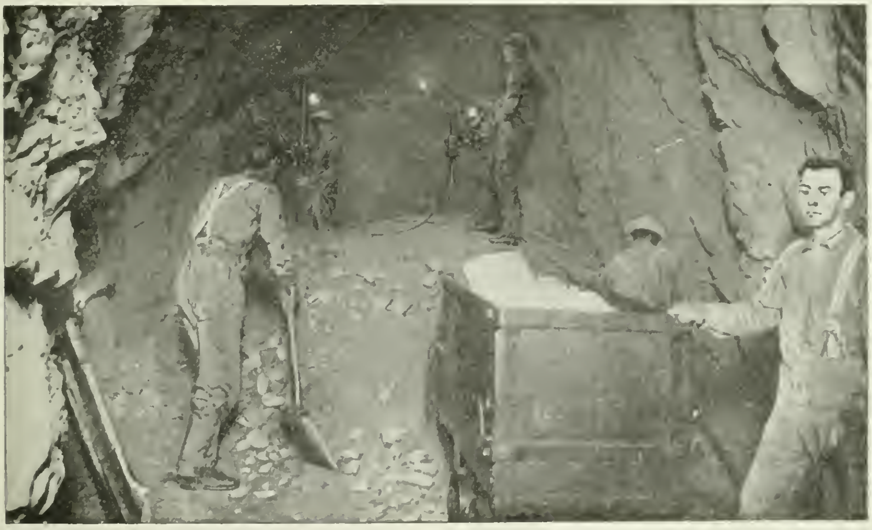
One dollar will buy a little over nine times as many heat units worth of crude oil as of gasolene, which would make its use far more profitable were it placed on the same basis of efficiency. Yet with the exception of a small number of large stationary motors, and a few portable motors of the farm implement type, the heavy oil consuming motor is not to be found. Certainly for the automobile type it does not exist. Setting aside the somewhat rare examples of stationary practice, most experiments which have been made up to this time in the way of the adaptation of the internal combustion motor to the use of heavy oil fuels have been directed at the carburetting apparatus. Yet it is by no means certain that such fuels can be carburetted in the ordinary sense. Certainly, the long delayed results of some of the experiments which have been made show that it is no simple matter, despite its apparent simplicity. A high degree of heat is required to complete the vaporization of the fuel, and a higher ignition temperature is necessary than with gasolene. These considerations, together with the more or less viscous nature of the fluid itself, render the use of the ordinary aspirating spray principle extremely difficult. On the other hand, the introduction of the fuel directly into the combustion chamber, after the manner made possible by the use of the mixing valve, or by the method of injection into a body of compressed air, is both unexplored and, in the latter case at least, attended with more or less mechanical complication. These difficulties, however, are not of necessity insurmountable, In fact, they are in no way comparable to some that have been overcome already.

COMPRESSED AIR FOR CAR CLEANING

At the recent meeting of railroad men at Atlantic City, a long discussion was had upon the cleaning of cars. It appeared that the cleaning of passenger coaches, and especially of sleepers, is quite a complicated operation and various devices are employed for the different details.

Mr. C. A. Schroyer of the Chicago and North-Western said: "There is something wrong with us when we come to cleaning cars and the cost of doing it. We clean about 400 cars a day in Chicago. We have one yard fitted up in what we consider a modern manner, with steam, with air, and with water. We use straight air for blowing out the dust upon the varnish and in the blinds and curtains, blowing it out of the cushions and backs, after first raising the windows and opening the doors of the cars, and if you get outside of that car when the work is being done you will see a cloud of dust being turned out of the car, but it is settling somewhere else. Now, what elements there are in that dust that might carry disease we do not know, but we do know that our car cleaners are a pretty healthy gang of men and women. I have thought a great many times that I would like to have the vacuum system, but we cannot have it in our yard unless we use it in connection with the straight air system, and we think that that costs us too much money, because straight air is pretty expensive. I have again thought that it would be wise to use the vacuum system in connection with steam, running steam pipes out into the yard and producing our vacuum."

Another speaker said: "I believe the almost universal practice at large terminals is to use the compressed air system for inside cleaning of passenger equipment, although I know of one or two instances where the vacuum system is being used. From what I have observed, and from conversations with others, I am led to the belief that the vacuum system is not as well adapted for the floors and carpets of cars as the compressed air system, but for seats and draperies the vacuum is probably preferable. In order, therefore, that the really up-to-date cleaning of cars can be obtained, a yard should be equipped with both systems, because cars could be cleaned better and in less time.



THE HEADING—SHOWING MUCK PILE CAR AND SHEETS IN OPHELIA TUNNEL.

RECENT PRACTICE IN TUNNEL DRIVING*

By W. P. J. Dinsmoor.

The Ophelia Tunnel in the Cripple Creek District of Colorado was driven for the purpose of draining mines, and transporting ore and waste from the deep levels of such properties as it might cut.

This tunnel has been driven to a point approximately 8,500 feet in a direct line from its portal. It is for its entire length nine feet by nine feet in the clear, and in places will show ten feet by twelve feet.

The tunnel was driven through granite, then into breccia, with intervening dykes of phonolite, andesite, and nephaline bassalt, at an average rate of 350 to 375 feet per month. Three hundred and fifty feet per month was considered low, and such a result called for an investigation by the management of the causes which reduced the work accomplished to this figure. The record month showed an advance of 395 feet and 8 inches. This speed in driving was obtained by careful planning of the work, so that there would be no loss of time or idleness for either the men or equipment. This required a thorough study of the conditions to be met and overcome, and careful oversight. The plant consisted of two 60 horse-power boilers; one straight line, two-stage air compressor; one high-pressure, three-stage, locomotive-charging compressor; one Porter compressed air locomotive and Sullivan 3⅛-inch drills.

PLAN OF WORK.

The working day was divided into three

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*Condensed from *Mines and Mining*, June, 1907.

shifts of eight hours each. In the actual tunnel driving work there were seven men to a shift; two machine drillmen, two machine helpers and three "muckers." Each shift was supposed to drill, load and shoot a round of from eighteen to twenty-two holes, drilled from 5½ to 7 feet in depth, as well as to load the "muck" resulting from the work of the previous shift into the cars, and deliver the cars to the compressed-air hauling engine. The management feels that under the three-shift plan the men do better work and take more pride in its results, owing to the fact that the men know that another shift is following close on their heels to perform the same operations that they have performed, and that the following shift depends upon the satisfactory completion of this shift's work for the accomplishment of their own.

The method pursued was essentially as follows: As soon as the smoke was cleared, the new shift of drillmen, helpers and "muckers" all went to work, and the broken rock from the face was thrown back sufficiently to allow the columns for mounting the drills to be put in place. The two drillmen worked together, and the two helpers worked together in pairs, relieving each other at intervals; the "muckers" going immediately to work, getting the "muck" into the cars and on its way to the dump. When the helpers were working on the muck pile, the drillmen were back of the work; looking up equipment; seeing that all the machine drills, steel, hose, tools, blocking, etc., that would be required for the shift's work were on hand, and, if anything was found missing, taking steps to secure it. When the drillmen were working on the muck pile, the helpers were employed in bringing the required material up to the face, where it would be readily available.

It may be objected that this would be possible only in a short tunnel, but in this tunnel, about one and two-thirds miles long, this work was accomplished by each shift every day. As soon as the muck was cleared away from the face, the columns were put in place; the drills mounted, and the drilling of the new round commenced.

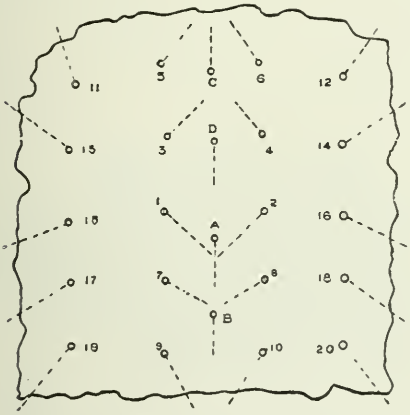
In clearing away the muck, care was taken that it should not fall back toward the face until a sufficient space was provided in which to set the columns. After the columns were set the muck was allowed, and in fact encouraged, to fall back, until it had filled the space in front of the face up to such a level that the tops of the jack screws of the columns could just be reached. By this method, the back holes, or those nearest the top of the tunnel, were the first to be drilled, and the drillmen and helpers worked from the top of the muck pile. This did away with any form of staging, and while the drillmen worked towards the bottom of the tunnel, the muckers were removing the pile, thus always giving the drillmen a standing ground of proper height, or really a self-adjusting platform, much wider and more solid than any portable timber staging. It was of course necessary for the muckers to finish loading out the muck before the drillmen reached the bottom holes or "lifters," but they did not stop work until the end of the shift was reached, as there was rail laying, and the placing of sheets, to occupy their attention until the holes were loaded and ready for shooting. Everyone on the shift was busy from the time he reached the heading until the holes were loaded and fuses split. The only time lost in the twenty-four hours of the day was that required for changing shifts and the clearing of powder smoke.

Full length mining columns were used in order to reduce the amount of blocking needed at the top and bottom of the columns, and to insure the removal of the muck from the face, clear to the bottom of the tunnel before the set-up, so that resetting would not be required when the bottom holes were reached.

Care was always taken to see that the men were well supplied with all material for their work. Empty cars were always kept at the face; an extra machine drill was constantly on hand, so that if one of the drills in use required repairs, it could be laid aside, to be put in order by a skilled mechanic. Thus the drillman and his helper were not delayed by making repairs. Plenty of sharp drill steel and water for use in the holes were kept close to the face.

ARRANGEMENT OF DRILL HOLES.

The important matter of properly placing and shooting drill holes was carried on as follows: In the illustration, holes Nos. 1 and 2 are cut looking down, and were so placed and directed that their inner ends nearly met. The fuse for these holes was so cut that they were fired first and nearly at the same moment. Holes Nos. 3 and 4 are cut holes, drilled looking up and about the same depth as Nos. 1 and 2. They were so directed that their inner ends did not meet, as in the case of Nos. 1 and 2. The fuse was so adjusted that these holes were fired just after Nos. 1 and 2. Holes Nos. 5 and 6 are the back cut holes. They were drilled looking up, and so directed that their inner ends did not meet, nor did they extend together beyond the top of the tunnel. These holes were shot together and just after Nos. 3 and 4. Cut holes Nos. 7 and 8 look down, and were timed to shoot after Nos. 5 and 6. Holes Nos. 9 and 10, the cut lifters, look down and extend below the proposed bottom of the tunnel. Holes Nos. 11 and 12, the back rib holes, and holes Nos. 13 and 14, rib holes, look up. Holes Nos. 15 and 16, also Nos. 17 and 18, rib holes, and holes Nos. 19 and 20, rib lifters, all look down and all extend beyond the line of the side walls, and were all shot at nearly the same time.



ARRANGEMENT OF DRILL HOLES.

Where stiff ground was encountered holes A and B were put in, and shot with holes Nos. 1 and 2 and Nos 7 and 8 respectively. Where very stiff ground was found, holes C and D were added and shot with holes Nos. 5 and 6 and Nos. 3 and 4 respectively. By analyzing the above it will be found that holes Nos. 1 and 2 take out or loosen a wedge-shaped portion of the rock, thus relieving the resistance to the action of the powder in holes Nos. 3 and 4 and holes Nos. 7 and 8. Holes Nos. 3 and 4 and Nos. 7 and 8 clear the way for holes Nos. 5 and 6 and Nos. 9 and 10. Holes Nos. 9 and 10 have a tendency to throw any broken rock above them out of the way of the remaining rib holes. Holes A, B, C, and D serve simply to increase the effect of the holes with which they are shot. By placing the holes in this way and shooting in this order, the break, with very few exceptions, always cleared the rock for the full width and depth of the tunnel, thus doing away with the necessity of following the heading with any work designed to break off projections.

Tamping material for use in the loading of the holes was always employed. It was found that by using this, the results obtained were most satisfactory, and that less powder was consumed.

HANDLING THE MUCK.

Two tracks were maintained close to the heading. Before the shots were fired, steel sheets were placed on the floor close to the face, extending back far enough to receive all the broken rock. It was found important to have these sheets weighted, and enough muck was kept at the face to do this properly. The sheets formed a smooth floor from which to shovel the muck, but unless the sheets were weighted, it was found that the vacuum created by heavy shots was likely to lift them and mix them with the muck, thus not only defeating the purpose for which they were intended, but actually increasing the labor of mucking. The sheets behind the main portion of the muck pile served to receive part of the muck thrown from the face, and also to facilitate the handling of cars.

A convenience for saving time was the use of a flanged valve on the heading end of the pipe line, instead of the screw valve commonly employed. There was also a telephone system, one station of which was kept well up toward the heading. In case of accident, or when it was necessary to communicate with the portal or power house, the use of the telephone saved valuable time.

VENTILATION.

The removal of powder smoke after shooting was accomplished by means of a blower and the compressed air system. As soon as the work of drilling stopped, the engineer would notice the fact that the demand for compressed air had ceased; he would then fill the receivers and pipe lines with air at 100 pounds pressure. After the holes were loaded and fuses split, the drillmen would open the gate valve at the heading, allowing a full stream of air under 100 pounds' pressure to play on the face through a 1-inch whistle cock. This volume of air, coming with a high velocity, stirred up the smoke and mixed thoroughly with it. The pressure in the pipe lines dropped rapidly and as soon as it reached twenty pounds the engineer started the compressor and kept the pressure up to that and also started the blower, if it was not already running. A 15-inch ventilating pipe was used and the smoke was soon thoroughly mixed with fresh air. It was seldom that the men could not get to the face twenty minutes after the shots were fired.

For various reasons the costs for this tunnel cannot be given, but figures shown by the management compared with figures for other tunnels driven under similar conditions of ground. cost of labor, fuel, powder, etc., show the cost of this tunnel to have been very low. The men were well paid, but no bonus was given for progress above the average rate per month. The work was done thoroughly; the alignment and grade of the tunnel were kept perfect and it would seem reasonable that it was the methods employed which assured the rapid headway and the low cost per foot.

OIL PNEUMATIC GOVERNOR

The function of the governor here illustrated and described—designated as Type N and manufactured by the National Brake and Electric Company, Milwaukee, Wis.—is to automatically control the operation of an air compressor driven by a series wound motor, stopping it when a predetermined maximum pressure is reached. and starting it again when the pressure falls to a predetermined minimum. It works automatically by making and breaking the electrical circuit to the motor as the pressure reaches the limit upward or downward. It is a purely pneumatic governor, no troublesome magnets or complex levers being employed. The only electrical features are the two terminals and the switch-arm which makes the connection between the terminals.

Fig. 1 is an external view of the governor complete; Fig. 2 is a vertical longitudinal section, and Fig. 3 is a plan of the apparatus with the cover removed. The external dimensions of the case are 15x7⅜x4⅛ inches. This case is constantly filled with oil, its capacity being three pints. Any good quality of mineral or transformer oil free from carbon, fishy or other organic matter, may be used. The oil entirely surrounds all working parts, preventing rust and wear, and it thoroughly suppresses the arc which follows the breaking of the electric circuit. There is no deterioration of the oil in use and it will last for years without replacement. The containing structure of the governor permits ready access to the mechanism for adjustment by those authorized, but not by a meddlesome motorman.

CONSTRUCTION.

Into the containing case are cast the keyways for fastening the forward end of the extension operating spring (21) and the contact arm stops. The piston (12) is equipped with double cups or gaskets (24), made of a special composition, which is not affected by oil. The piston (12) works in the air chamber guided by (3) on the opposite end of the piston rod. The piston rod carries the operating spring (21) and a spring adjusting yoke or collar (19) at its forward end, to which the controlling spring is secured. The adjusting yoke is provided with a washer (20) the tension of the spring being adjusted by nut (19). The cylinder end of the spring is held in a containing box by the two keyways referred to above. These keys are shaped in such a way that the spring is held very rigidly.

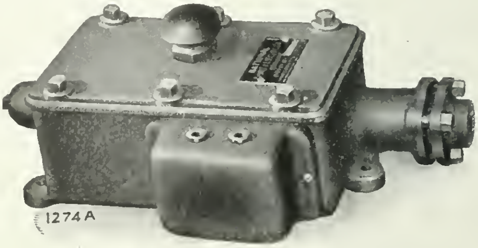


FIG. 1—OIL PNEUMATIC GOVERNOR.

The cylinder is tapped directly to the reservoir, so that the piston is always subjected to reservoir pressure and no waste of air can occur. The piston rod is threaded at its lower end to receive the adjusting nuts (17) for varying the range between minimum and maximum pressures. These adjusting nuts are made round instead of square, and are adjusted by means of a spanner wrench, which militates against the temptation of a motorman with a monkey wrench, to tamper with the adjustment.

A trip hammer of the kodak shutter type and made of brass, is pivoted on a post (37) between the adjusting nuts, its function being to trip the switch arm to open and close the electric circuit. The trip hammer mechanism which actuates the switch arm is accelerated by action of the spring (29) supported on a pin (25), and fastened at one end by means of the pin guide (30), which is supported at the trip-hammer end by means of a movable metallic block or eccentric device working between parallel jaws, cast as an integral part of the trip hammer. The other end is secured to the wall of the containing case by means of toggle pin (26), which fits in lugs cast into the governor case. A smaller, shorter spring (28) of one-eighth the power of the trip hammer accelerating spring, and separated from the former by distance piece (27), prevents vibration of the switch arm when the circuit is open.

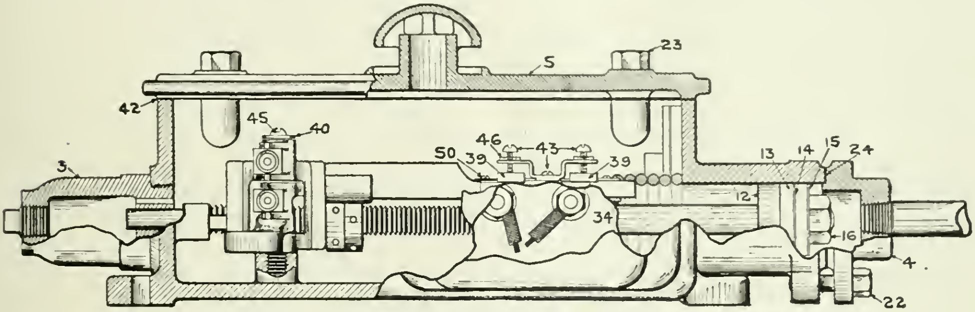


FIG. 2—OIL PNEUMATIC GOVERNOR.

The switch arm (18) is made of a special insulating material. Being always under oil, no deterioration of the insulating material can occur. The motion of the switch arm in either direction is limited by stops cast into the end of the containing case.

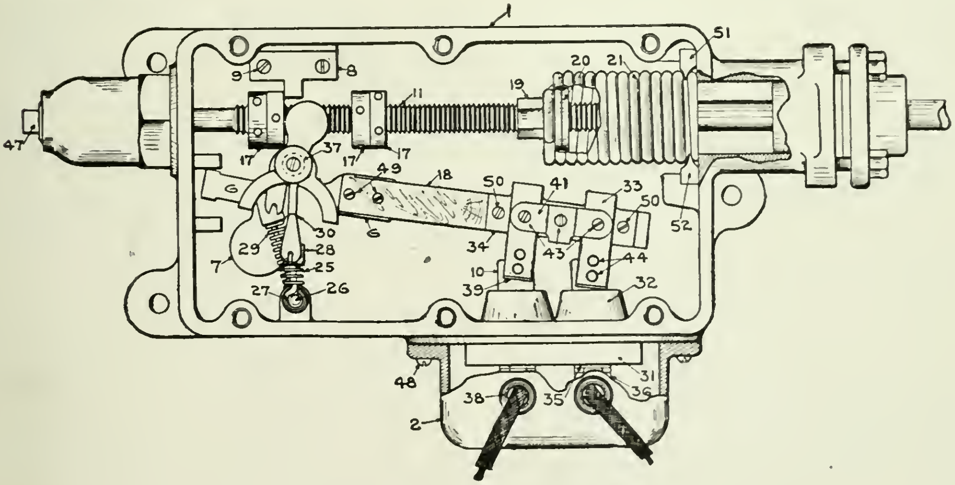


FIG. 3—OIL PNEUMATIC GOVERNOR.

The moving switch blade contacts (39) are of heavy square phosphor bronze and are adjusted by means of screws (43) and adjusting plate (41) so that the area of wiping contact may be increased or decreased as may be required. The stationary electric contacts (10) are heavy, square plugs, and are insulated from the governor containing case by means of the heavy insulating bushings (32). Short-circuiting between stationary contacts and case is therefore impossible. The arrangement of the supporting screws for the stationary contact is such that they can be easily turned over to present a new contact for the switch blade if the occasion should ever arise, which will be rare. The two terminals for the electrical connections are placed on the side of the governor case and are thoroughly insulated from each other and the containing case by means of a

INSTALLATION.

For traction service the governor may be under a car seat as directly over the reservoir as possible. For stationary service, it may be located as most convenient, but not in a vertical position. It should be connected to the thick fibre block (31) which eliminates all danger of short circuiting. The two terminals can be either trolley or motor connection, respectively, without affecting the working so that a wrong connection cannot be made—a feature not possessed by any other governor. receiver as directly as possible to avoid compressor pulsations in the piping.

OPERATION.

This governor is equally adapted for operation by either direct or alternating current, and its performance is not affected by variations of voltage. It also is entirely independent of gravity or outside forces. When the compressor is in operation and the air pressure increases, the force of the piston at once begins to extend the operating spring. When the pressure approaches the maximum the upper adjusting nut forces the projecting end of the trip hammer over its center, causing it, with the assistance of the accelerating spring, to deliver a quick blow to the switch arm, which immediately knocks it out of contact and opens the circuit. The arc which results is instantly suppressed by the oil. The design of the trip hammer mechanism is such that its inertia is small and almost frictionless. When the air has thus acted on the piston and the pressure has been reduced this causes the operating spring to return the piston, at the same time moving the hammer over its center in the opposite direction and causing it to strike the switch arm and instantly close the circuit.

SOME LATE IMPROVEMENTS ON COMPRESSIVE RIVETERS AND OTHER PNEUMATIC TOOLS*

By Chester B. Albree,

President Chester B. Albree Iron Works Co., Allegheny, Pa.

COMPRESSIVE RIVETERS.

In compressive riveter work there are two or three types which are quite familiar, the oldest type being the straight hydraulic machine invented by Tweedel in England, and, later on, the pneumatic riveter by Allen of New York, who was perhaps the first to make it a success. Later came the hydro-pneumatic riveters. With the hydro-pneumatic riveter we have been making some experiments, and it has been found advisable for several reasons, notably for greater economy of air, simplicity of construction and better action, to try to improve the methods that have been in use. In the operation of driving rivets the pressure required differs from that for punching materials, in that in punching your greatest pressure comes at the first of the stroke, when the punch comes down on the material. In riveting, however, especially hot riveting, the easiest work is when the die first strikes the rivet and the greatest pressure is required to finally form the head. That being the case, it can readily be perceived that a constantly increasing pressure would be the theoretically correct pressure to drive rivets. This pressure is most easily obtained by means of the toggle joint, which theoretically gives an infinite pressure with an infinitesimal movement at the end of the stroke. In practice, of course, we do not get an infinite pressure; but, as most riveters are of horseshoe or yoke type, the limit pressure is the yielding point or the bending point in the yoke. In straight toggle joint machines the general idea is shown in Fig. 1.

In practice we find that when the cylinder has made seven-eighths of its stroke the pressure line of the rivet dies rises up to about fifteen times the pressure in the cylinder. By that time we would have traveled within about 1-16 inch of the end of the stroke of the machine, and beyond that point the probabilities are that there would be spring in the yoke. If we made the yoke strong enough not to spring at all, it would be so heavy as to be utterly unmanageable. So it is only necessary that deflection should not occur at a pressure below that necessary to drive the rivet. Hence in the toggle joint arrangement we have the best possible arrangement for driving rivets.

But there are certain drawbacks in the practical application of the toggle pressure. The principal one is that its stroke is absolutely fixed. It never varies for a given leverage. In riveting, you are liable to have 1 inch or 2 inches, or maybe only ½ inch thickness of plate, and in order to have the maximum pressure just as the die comes to the surface of the plate, it is necessary to adjust the distance between the die and the point of maximum pressure by means of a screw actuated by hand. In work that does not vary it makes little difference, but in ordinary structural work, and boiler work, you have constantly to drive rivets through different thicknesses of material, and each time it will be necessary for the operator to adjust the screw. This requires a certain amount of skill, and if it is not done correctly the chances are that you will not drive the rivet sufficiently tight, if you do not close it with maximum pressure.

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*From a paper presented before the Engineer' Society of Western Pennsylvania.

To overcome this difficulty of adjustment the hydro-pneumatic machine was devised, which is nothing more nor less than a hydraulic intensifier. The ram alone gives a very small but powerful motion, and as it is necessary in riveting to have clearances, in order to go over angles, stiffeners, etc., so it is desirable to have a longer stroke. Of course we do not need high pressure over a longer distance than, say, 1¾ inches. The question was then how to get a clearance movement. This was accomplished by putting a little auxiliary cylinder below the air cylinder. The air pressure acting on its piston forces liquid into the ram cylinder at low pressure, and by this means we get 3 or 4 inches of preliminary adjustment.

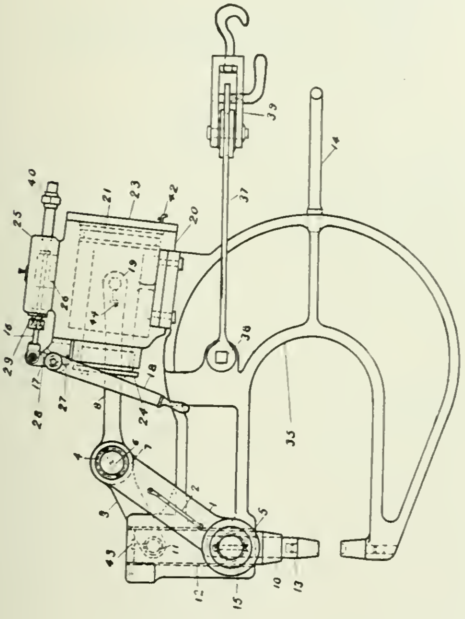


FIG. 1.

The objections to this form are, in the first place: that it is very difficult to pack; and second, that in order to get two inches of die motion with a maximum pressure of 50 tons, it requires a 15 to 20-inch stroke in the air cylinder, and a very high pressure throughout this stroke in the ram cylinder and plunger cylinder, sufficient for the final closing pressure, thus wasting power. The practical advantage is that it does not require skilled workmen to adjust the dies; they adjust themselves. It occurred to us that we might get the desired toggle joint effect and yet have an automatic adjustment, and what I want to speak of is the device for the accomplishment of this, which may be of interest to you.

In Fig. 2 is shown our first attempt and also our perfected form. As far as the toggle joint action goes, it is practically the same as that of the first machine described. The pressure from the toggle, in the first form machine, is transmitted from the large area of the plunger to the top of the ram, and also through a pipe to the adjusting cylinder. The ram, being smaller in area and free to move, advances more rapidly than the plunger and continues until the rivet die on its extension strikes the projecting rivet. As the plunger continues, the pressure in the cylinder is limited by the pressure due to the spring in the adjusting cylinder, which is only 20 pounds per square inch, insufficient to upset the rivet beneath the ram. Hence the liquid will now displace the piston in the adjusting cylinder, the ram remaining stationary. As soon, however, as the projection on the plunger enters the ram cylinder the full toggle pressure is transmitted through the incompressible liquid to the ram, forcing down the rivet, and the differential area above forces the remaining liquid in the large plunger bore into the adjusting cylinder.

During the downward motion of the ram the liquid beneath it is forced into the opposite end of the adjusting cylinder; against the spring pressure. It is obvious that the ram may move its whole adjusting stroke, or none at all, up to the time that the projection on the plunger enters the smaller area; after which the further travel of the ram is that of the plunger until the ram meets opposition greater than the pressure of the toggle, when it will stop. This arrangement, therefore, automatically adjusts the point of maximum pressure to suit the work. On the return stroke we have the direct pressure beneath the ram, as well as the suction of the plunger, to raise the ram to its original position.

Theoretically this design was correct, and it worked very well indeed for about two strokes. At the end of the second or third stroke our packing was gone, and we have found it impossible to hold the pressures. The trouble lay in the fact that we put cup leathers at the end of the plunger, and when the cup leathers entered the chamber the moment the pressure rose to a high point it tended to cut the leather right out. So in order to make the device practically, as well as theoretically successful, it was necessary to devise some scheme to have the leather cups, which hold better than any other hydraulic packing, move always surrounded by the walls of the cylinders, and pass no ports whatever. To do this and yet allow the liquid to pass freely from the upper to the lower part was rather a difficult proposition. We accomplished it in this manner.

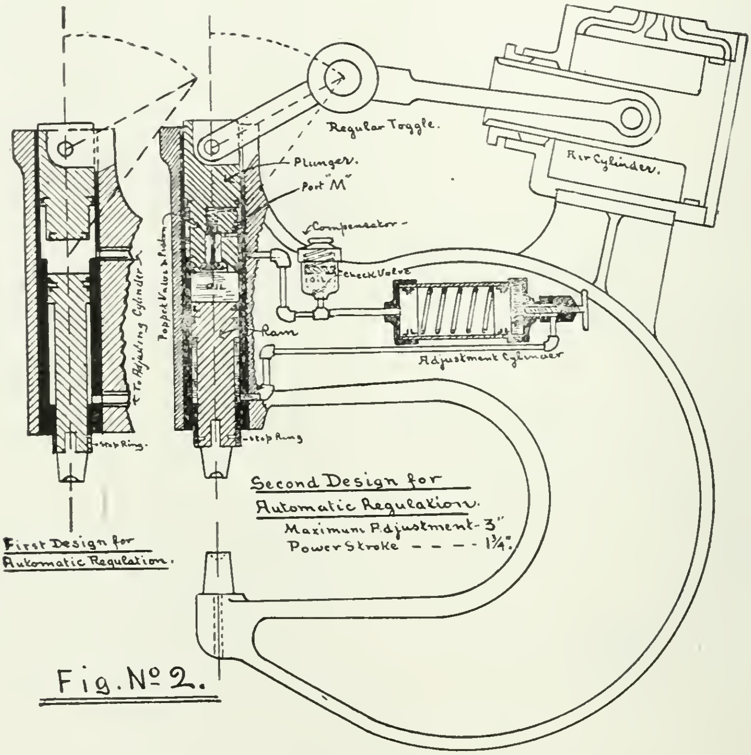


Fig. No 2.

Referring to the later form in Fig. 2 it will be noted that the extension of the plunger, when fully up, projects into the smaller area of the ram cylinder, and that cup leathers are used to pack it. In the interior of this extension is a valve of the poppet type, but having a stem carrying on its end a small piston. This valve is normally held open by a spring. So long as the pressure above and below this small piston is the same, the spring holds the valve open, but when the pressure below is greater than above the piston will move up, closing the poppet valve. This occurs only when the port *M* leading into the space below the small piston is closed, due to its passing from the large diameter bore to the smaller ram bore. When closed, the toggle pressure acts on the liquid below the plunger extension, raising the pressure sufficiently to move the small piston and connected valve, and later exerting very high pressure on the poppet valve, shutting it perfectly tight. The adjusting action is precisely the same as in the first type, except that the liquid flows through the plunger extension instead of around it, during the adjustment part of the stroke. With this arrangement it will be noticed that all of the closed by cylinder walls and pass no ports or openings, so that the packing leathers are not injured. I would say that the adjusting device is patented and the poppet valve device is now being patented.

In any device of this kind there is always a certain loss of liquid due to a film in the ram (although theoretically the quantity of liquid is constant) and in the course of a little while there would be a partial vacuum inside and pressure on a cavity would not give good hydraulic pressure on the rivet. It was therefore necessary to provide a constant source of supply of the liquid, so arranged that when the pressure rose in the confined liquid it would not blow out, but when there was a vacuum in the system additional liquid would run in.

This loss of liquid is made up from a small storage, or compensating cylinder, full of liquid, having a piston with a spring behind it, connected to the larger bore of the plunger by a pipe having a check valve in it. Whenever there is pressure in the plunger cylinder the check valve remains closed; but when the toggle is fully back, and the piston in the adjusting cylinder is against its cylinder head, so that no pressure due to its spring is exerted on the liquid, any loss of liquid will tend to create a vacuum in the plunger cylinder, and then the check valve will open and oil will flow out of the compensating cylinder under the pressure of the spring acting on its piston, to replace that lost.

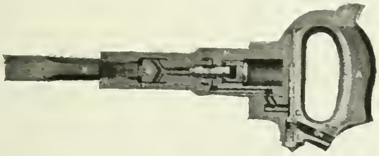
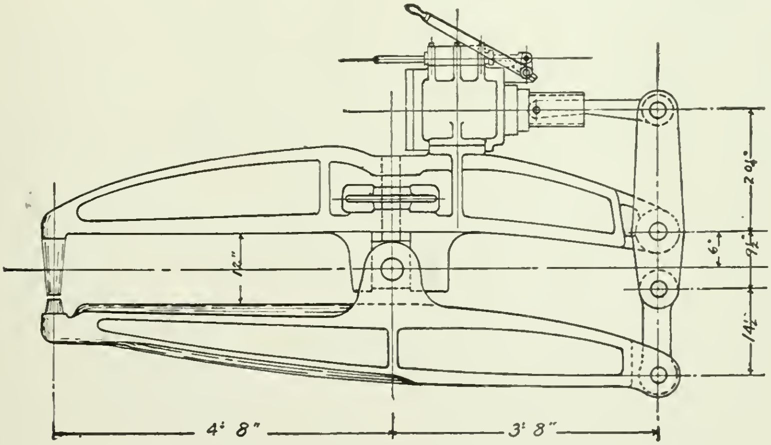


FIG. 3.—PNEUMATIC HAMMER.



Alligator Riveter –
Fig-No 4.

PNEUMATIC HAMMERS.

We have been working on pneumatic hammers and have now perfected a hammer one or two features of which are novel and of interest. In pneumatic hammers of nearly all makes, one of the sources of trouble has been that if the workman picked up the hammer and put his finger on the trigger when there was no chisel or rivet set in it, the piston would begin to reciprocate, and not having any tool to strike at the lower end it would strike the cylinder head, and in a matter of a minute or two it would smash the piston or cylinder. About 75 or 80 per cent. of the breakages of pneumatic hammers are due to the carelessness of workmen in pressing on the trigger when there is no work to do. We have devised a method of obviating this trouble which is very simple.

The admission port is located near, but not at, the end of the larger cylinder bore. When no tool is placed in the end of the hammer the lower end of the large piston diameter passes and closes the admission port, thus preventing air from acting upon the differential area to lift the piston. Any compressed air below the large diameter escapes by a small leakage port to the exhaust; and this leakage port is only open when the admission port is closed. In hammers actuated by valves exterior to the piston, it seems impossible to use this device, and attempts have been made to mechanically close such valves, but they do not appear to be very successful. The same effect is obtained, but at the expense and loss of air, when the leakage port is designed to open when the piston is at the extreme end of the stroke, but does not close the admission port. Patents are now pending for these improvements.

This simple device is very effective. We can pick up a tool and with 100 pounds air pressure in the pipe, put your finger on the button, open the throttle, and it does not start unless the tool is fully in place, whereas with any other tool that I know of, the moment you put your finger on the trigger it begins to work, and it is only a matter of a few minutes until it is good for nothing.

A SPECIAL RIVETER.

I might speak of another machine which was built for some special work that has a feature of interest. The work to be done was the riveting of some concrete mixers, they being in the shape of two cones with their bases placed together. The problem was to reach into a very limited space and drive the rivets. They had been doing it by hand, and wanted something a little quicker than the pneumatic hammer and something that gave tighter rivets. They wanted a power machine. It was necessary to have a reach of some 50 inches and we had an extremely small opening. At the same time it was necessary to be able to adjust for different thicknesses of material, and to give what we call an alligator motion to the jaws of the machine. The ordinary riveter could not be used for this work.

To secure adjustment of the projecting alligator jaws of the machine, we inserted a screw carrying the trunions of the fulcrum on one end. A hand wheel, with thread in the hub, serves to raise or lower the screw, thus adjusting the distance between the ends of the jaws as desired, and at the same time not interfering with their clearance or action. The details of the machine are plainly indicated in the cut. It is provided with a universal bail, so that it can be used in any plane at any angle.

We also designed a special carriage to hold the double cones, rendering it unnecessary to raise either riveter or cones, but only to revolve the cones on their axes.

I might mention one other thing which I believe will not be quite new to you, and that is a method of riveting boilers in a horizontal position. We made a wheeled truck carrying on its bed three sets of rollers running in the opposite direction. We suspended from a trestle a riveter large enough to do boiler work from a bail attached through a system of sheaves and tackles to a counterweight of one-fourth the weight of the riveter and having four times the travel. Then all that was necessary to do was to have a small chain block on the trestle to overcome friction of the sheaves and tackle. In that way we could raise this machine with a chain block for any diameter of boiler.

We have in very successful operation a machine with a 10-feet 6-inch gap, weighing about 25,000 pounds. We are now installing several other machines of this character, and it seems to be quite a feasible plan. It has several advantages over the ordinary Tower system. It takes up very much less room and the initial cost of installing the plant is very much smaller. This system requires no hoisting of the boiler, as it is simply rolled on the floor or on the rollers. Thus the power plant of the machine is limited to that necessary to actuate the toggle.

COSMOPOLITAN ENTERPRISE

Five Frenchmen, all residents of Paris, have incorporated a company in New Jersey to work copper mines in Spain and filed articles of incorporation with the county clerk at Jersey City the other day. It is known as the Lealtad Copper Mine Company and is capitalized at $500,000. The incorporators are J. Duggue de la Faucon Nerie, Dr. René le Fournier, Dr. Jacques Hulat, Amand Galbrun, Felix Broose and Benjamin Treacy, of No. 15 Exchange place, Jersey City, who is the resident incorporator.

Seven miners were suffocated by "white damp," or carbon monoxide, on July 11 in an abandoned working of the Lehigh and Wilkesbarre Coal Company, at Honeybrook, Pa. Two of the men had been sent in to measure the water; then two more went in to assist them; later, in the belief that the force was inadequate, three more were ordered in. When the men did not return a rescuing party went in and discovered the presence of the "white damp"; the rescuers themselves were overcome after recovering but one body. "White damp" is the most treacherous and difficult to detect of all mine gases; it cannot be detected with a safety lamp, which burns brightly in it. It is a narcotic poison of rapid effect; 1½ per cent. of it in atmospheric air will cause death. It results from mine fires and imperfect combustion and is found where heavy blasts have been set off and subsequent ventilation has been inadequate. A ventilating fan to clear the workings was installed after the accident.—*Engineering News.*

COMPRESSED AIR

Established 1896.

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INFORMATION PRECEDING IMPROVEMENT

The article in the present issue which deals with "A Month's Output of Air Compressors" by a single manufacturing company, brings out several points of interest. To us at the present moment the thing most prominent is the variety and diversity of the industries in which compressed air now finds employment. The list given in the article is, after all, only a hint of the range of employment, for the sales of each month would continually extend the field. We may certainly say that notwithstanding the diversity of employments indicated the use of compressed air would be much more extensive than it is if all were familiar with it, as comparatively few still really are.

The air compressor is no longer dependent, as at the beginning, upon the rock drill as its employer. It finds other work all the while for itself, and it makes its way by first making acquaintances and then friends. It is now the most familiar experience that wherever a compressor is newly installed and compressed air is given employment for the first time in any establishment, say for operating a few hoists or for a pneumatic tool or any other special apparatus, the air invariably soon finds other work to do and the compressor originally installed is never big enough.

Railroad shops have done more than most others toward familiarizing workers generally with the handiness and the ever-readiness of compressed air; and this has come, as we all know, from the fact that in the beginning it has been so easy to set up an airbrake pump to supply, say, one or two air hoists, these being the things usually so first employed in railroad shops. Soon compressed air is connected to do some other operation, a second pump is called for and then a third, until sometimes a dozen airbrake pumps have been set up before the railroad men have learned, or at least have realized, the extravagance of them as power wasters rather than compressed air producers.

The users of rock drills and of other air operated apparatus, and especially coal mines, have generally been content if only sufficient air has been supplied for their present purposes, with little inquiry as to the efficiency of the machines, and it is only after years of extravagant and easily avoidable waste that they are beginning to realize the savings which may be effected, the realization only coming with fuller and more correct information as to what may be done, and especially as to what is actually being done by those who are most successful and who are realizing the largest profits. If the information which is ultimately proving effective had been earlier and more widely distributed the results of it also would have been more satisfactory.

Compressed air is getting new employments continually and the use of it is increasing more rapidly than ever before. The numbers are vastly increasing of those who for their own good need to know more than they do of the winning details of compressed air practice. Information in this line it is the life business of this publication to supply. It proposes to do its work thoroughly and faithfully, and it is entitled to the help and encouragement of those who have it in their power to make the way for it.

THE DEVELOPMENT OF NEW NAMES

We don't always realize our responsibilities at the critical moments. The making or the placing of names for new things is a case in point. The Linotype people, we understand, constantly regret that the name of their modern mechanical wonder is not pronounced as they intended, and therefore does not carry to the public the essential idea intended to be conveyed. The work of the machine, as we all know, is to cast a line of type, and the name was meant to be line of type, line-o'-type, lineotype. Unfortunately, perhaps some "simplified" speller had a hand in it, the letter "e" was left out of the word and it is pronounced, with dictionary authority, too, as if it was spelled linnotype, with the first syllable short, and the basic idea consequently is lost.

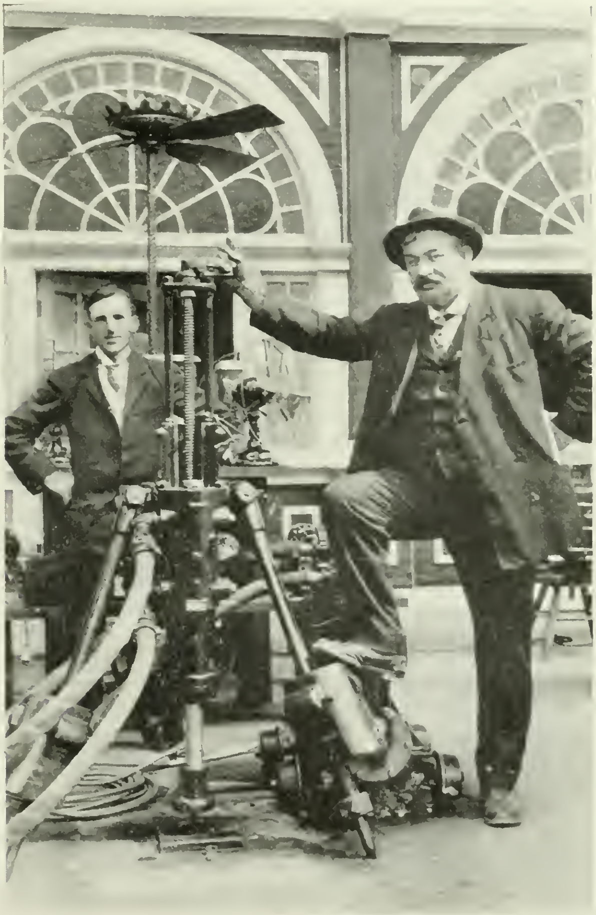
Another case, in which, however, the conditions are as different as can be, is that of the Electric-Air rock drill. Here, also, there has been the intent to produce a name which would correctly characterize the thing, and here, also, the result has been anything but a success. The name certainly carries its suggestions. There are electric drills and there are air drills. The friends and promoters of the Electric-Air drill might from the name claim for it all the good qualities of both, and the enemies and competitors of it might say that it embodies all the objectionable features of each, but either way of taking advantage of the name would, upon investigation, fail, for the name is a double misnomer. It might quite truthfully be said that the Electric-Air drill is apparently so called because it is neither an electric drill nor an air drill. It certainly is not an electric drill, as the electric current does not come in contact with the drill in any way nor within several feet of it, and while the actual electric drills which have been tried have made such a poor show in the world, it is a heavy handicap on a new drill to have the same family name. So too, the drill is not an air drill, as such drills have heretofore been known, with the piston alternately driven in one direction and then in the other by direct air pressure, and the air for each stroke at once exhausted into the atmosphere. The action of the air in this drill is so different that the fullest knowledge of the regular air drill is, to the extent of its completeness, a disqualifier for a correct understanding of this.

Then, again, the little portable electrically driven air compressor which is a part of the apparatus of each Electric-Air drill is not an air compressor, and its name is another misnomer. That is, it does not do what an air compressor is understood to do. It does not take in successive charges of air from the atmosphere, compress the air and pass it along and then take in more, and so on. It plays the same air back and forth, and is, in fact, a pulsator rather than a compressor, and not being a compressor, neither the good nor the bad qualities of a compressor are properly assumable for it in consequence of its false name.

This apparatus is so novel and revolutionary, and promises to make for itself such a place in the industries of the time, that it deserves a new and distinct name all its own, quite as much so as did the Kodak. It is no wonder that the dictionary grows and that after all it is always behind. New things spring into being which none of the old names fit, and so there must be new ones continually. Things which do things, things which have to be talked about, develope handy names of their own, and we may expect one before long for the Electric-Air drill. The little motor boats on the St. Lawrence are locally known only as "put-puts."—*Cassier's Magazine.*

THE ELECTRIC-AIR DRILL AT THE JAMESTOWN EXPOSITION

The half-tone on this page appears here in its own right, being well worth looking at for its own sake, and we trust our readers will appreciate it as we do. It shows the Electric Air Drill at the Jamestown Exposition, in the exhibit of the General Electric Company. It beautifully illustrates the coöperation of electricity and air in the world's winning work. While surrendering none of its attributes as a pneumatic apparatus, there was still nothing more entitled to a place in an electric exhibit than this, for electricity is its only source of life and power. It is one of the successful and satisfactory inventions, such, for instance, as the switch and signal devices, which enable the electric current to do its most effective work only by the aid of the air. It encourages the hope that compressed air may find many other opportunities to make practicable and profitable the employment of electricity in the responsible operations of our various industries.



ELECTRIC-AIR DRILL AT THE JAMESTOWN EXPOSITION.

COMPRESSED AIR IN RAILWAY SHOPS

The presentation at the Central Railway Club of the interesting paper by Mr. W. P. Pressinger, which we printed in abstract in the preceding issue, was followed by an interesting and suggestive discussion, portions of which also are here reproduced:

TIGHT PIPES.

Mr. J. O. Gould—We have a number of miles of our air piping under ground. In laying the same out, we divided it up in sections by placing valves so we could test out with pressure gages. We pump the line up to pressure, then close the several valves and shut down the compressors with the gages on at different points. If there is no perceptible drop we are satisfied that the lines, valves, etc., are tight.

OIL FOR PNEUMATIC TOOLS.

Mr. C. H. Potts—I notice the author says in his paper that he uses oil for submerging his tools. I would like to ask what kind of oil he has found the best? Also, the best lubricant for lubricating pneumatic tools after they have been taken from the oil bath?

Mr. Aldcorn—We generally use kerosene for the baths in which the tools are immersed and blow them out in the morning. Every company has its own oil. Different kinds are made. We use an oil made by the Galena Company called airoline. It is a light oil and will not congeal in the tools—that is, for the hammers. We also use for the drills a grease made by the same company, which is not a fluid oil.

INSUFFICIENT COMPRESSOR PLANT.

Vice-President McKenna—One part of this paper refers to the installation of the air plant. I think any of us who have visited any plant of any size have been impressed with the fact that it resembles to a great degree a sort of a crazy-quilt affair. I mean that apparently no complete design of the plant has been made in the first place; it has been a case of patchwork. The amount of air to be consumed at any shop or any plant for a certain period of time is the first matter to be taken into consideration. The trouble is that we are very apt to figure that it will take about so much air. Then we figure on a compressor about one-half of the size, feeling that the work will be intermittent in its character. The result is that we gradually add to the use of our air plant, and in a short time we find ourselves seriously handicapped by the lack of it. Carefully prepared plans should be made, keeping in view the actual requirements at that time Then, owing to the increased consumption which will certainly develop later on, and by the installation of large compressors and large pipes, I think the results will be much more satisfactory than are obtained at the present time in many plants. In laying out pipe lines, either in shops or in yards for testing, means should be provided for return movement. Plants are often seriously handicapped by depending on the one main line. In the event of accident no means are provided for carrying on the use of the air. The piping should be laid off in sections, with suitable valves, which not only gives the benefit of the air being available in every direction, but also, as has been referred to here, testing up in certain sections becomes possible.

CARE OF PNEUMATIC TOOLS.

Mr. Hogan—The care of tools is something that is very interesting to watch. Sometime ago at the Depew shops we were not getting the service we thought we should from the air tools we were using. Our general foreman looked into the matter and found that they were not given the care and attention they should have, particularly in the way of lubrication, they were wearing out very fast, and they were thrown about promiscuously as though they were not valuable. But after we took the matter in hand and organized a system of caring for them it increased the efficiency of the tools and the output of the shop.

Mr. McKenna has touched on a very important point in connection with the use of air, *i. e.*, proper installation, piping, etc. We know, too, from experience, that good results can be obtained from installing return pipes or putting in valves that will permit of control of different sections throughout a large plant, particularly in case of accident.

Compressed air is indispensable so far as large shops are concerned, but it is costly if not properly looked after. No matter how large a compressor we install, if we permit leaks to develop and give them no attention, it costs considerable money to compress air. The proper methods for producing air, and utilizing it after it is produced, have been pretty well developed. It is now up to us to give them proper care.

Mr. Wanamaker—I would like to ask Mr.

Aldcorn how often air tools should be oiled while in use?

Mr. Aldcorn—That is another thing that depends on the air you are using, whether your air is moist or dry. If you are using air that has no moisture, you might have to oil—well, take a drill; if you are using grease in it or solidified oil, about twice a day. A hammer ought to be oiled oftener, because you use very light oil in it—probably three or four times a day. Our experience has been that if you use an oiler or atomizer, so that you can feed the oil in steadily, you will get better service out of your hammers and they will last much longer. We mention that in the paper, the using of an oil cup to atomize the oil into the hammer. Of course you cannot do that with a drill because it takes so much more.

Mr. E. A. Miller—I do not think too much can be said in regard to the merits of compressed air in our shops. As Mr. McKenna has said, our air plants have, like Topsy, "just growed," without much system or regularity, and there are very few shops to-day that are using their air plants to the best advantage, especially from this cause. The proper way to find the leaks is to have the plant provided with stopcocks so that it can be divided off into sections, and frequently, in the evening, when the shops are closed, or at such time as it may be found best, to have the lines pumped up to full pressure, the pumps stopped and let the gage show to what extent there are leaks. Then let the inspector close the shut-off cocks of different sections of the pipe, apply a gage to each section, until the part of the pipe where the leaks have developed is shown. That saves an inspection of the entire plant because it locates the leak in the section of the plant without going over the whole plant. By doing this the pipe lines can be kept up with the minimum amount of labor. Another thing that is very essential at the present time is the educating of men to the necessary care of closing valves and cocks and connections, to avoid the waste of air when they are not using it. Men generally consider that air doesn't cost anything. It doesn't as we breathe it, but it does when it takes coal to compress it. The importance of educating men to the proper handling of the air is one of the problems that we have before us at the present time.

The problem of getting plants systematically and properly installed is another important matter that we have before us. It is so easy for the foreman of some department who wants air some place to get pipe, possibly from the scrap pile, put in his connection and install his air plant. In a very short time it is wasting more air than the plant is worth. Then, too, we must understand that many men are being benefited by the air who have never given any thought to the economical side of anything connected with machinery. For instance the laborer is benefited by the use of air as well as the high-priced mechanic. I remember when I was working at the vise that about the hardest part of the labor I found in fitting driving boxes was placing them on and off the axle to try them. Now the man touches the valve and the air lifts the driving box and places it on the axle in much less time than he could lift it by hand. The men have had no knowledge of the economy that should be practiced in watching for leaks and economically using the air. Air is being applied in many ways to lighten labor and quicken work, from the highest priced mechanic down to the cheapest labor that we have. The important thing is to use the air sensibly; to head off the fellows with all sorts of fads and fancies who could do the work quicker and better without the air. To use the air economically he should have the plant provided with necessary valves and proper couplings; divide it up into sections, that it may be inspected quickly to determine whether there is a leak, and if there is a leak to know in what section it occurs. These are the important points.

Then take care of the tools. I am glad that emphasis has been placed by so many of the speakers to-day upon the care of pneumatic tools. The first hammer that we used cost $110. You can get such a hammer now for $60 or $80. But they were new at that time, and when we made the requisition I said to the storekeeper: "Now, when that hammer comes let me know; I want to see it." A few weeks later he came into my office carrying the hammer in one hand and the bill in the other. He said: "Here is one of the fixtures for that hammer, but the hammer hasn't shown up yet." "Well," I said, "that is the hammer." He exclaimed, "My goodness! you say that little thing cost this amount of money?" holding up the bill for $110. "Yes," I said. "Well," said he, "I don't understand it." "No," I said, "I suppose not." Now there are many people just like that storekeeper. They don't understand the pneumatic tool. They don't understand that in that simple little tool there is $110 or $140 worth of machinery. They throw it around, taking no more care of it than they would of a monkey wrench or a common chipping hammer that they use every day. It is incumbent upon those in charge of plants to educate men to the importance of taking care of these tools just as they would of any high-class machinery or of our plants, and also to teach them to use the air sensibly in all varied work.

RECEIVER CAPACITY.

Mr. J. P. Wright—Speaking of the main air line I would call attention to the fact that it should have proper reservoir capacity. The air pipes should be large so that you can always depend upon them for a reservoir when you have an unusual draft upon your power. Besides that, you can get a better joint with a big pipe. These air systems are usually installed by contract. The contractor cannot cut down the size of the compressor specified, but he can and he does cut down on the size of the pipe. This is where the fault comes in in the installation, and where most of the trouble occurs later on.

EXPERIENCE WOULD DOUBLE CAPACITY.

Mr. Aldcorn—I would just like to say a word about installation. If people putting in air plants would call in people of experience it would save them much trouble. Our practice has been, if a man ask our opinion, to tell him the experience of others; that is, of putting in too small a plant. We advise him to put in a compressor of probably twice the capacity he seems to need at first. If he has any sort of plant we will guarantee that within a year he will have another one just the same size. Where one very large compressor is required we advise that it be installed in two units, which I think is a great deal better. You can't put in too large a pipe line, but you can put it in too small. You cannot give your pipe line too much care, as to leaks, etc.

I have in mind one plant that has 16,000 feet of free air a minute going through the mains every day in the week. They use an 18-inch main line through the yard, and their branches are 6-inch. These lines are tested once a day. They have one man who does the testing and nothing else. He does it at the noon hour, the main line first, shutting off all others, and of course pumping up and having full pressure on the receivers. They have receivers with pressure gages all over the yard. After testing the main line he tests each of the outlets, one after the other. If he finds a leak it is repaired at once. The president of that company told me that man pays his salary ten times over. You know it takes about one horsepower to compress five cubic feet of free air per minute to 100 pounds; also that a little hole, a sixteenth of an inch in diameter, will leak out a horsepower.

LOSSES IN POWER TRANSMISSION AND TRANSFORMATION

The following appeared a short time ago in the form of a letter to *The Engineer*, London. It is interesting and readable, and tells its own story all through. The writer says:

"Sir.—I remember seeing in my early days a manganese mill driven by a water wheel. The water for working the wheel was pumped from the tail-race of the wheel by means of a Newcomen steam engine into a pond, from which the wheel took its supply. The combination formed a means of transmitting and accumulating power, for it is obvious that the engine might be kept pumping while the mill was idle. I see that such a system is proposed for working the machinery of the mines in South Africa. Turbines at the Victoria Falls—700 miles away—are to pump water into a pond on the Rand, from which the Rand mines are to take their power by means of other turbines and motors.

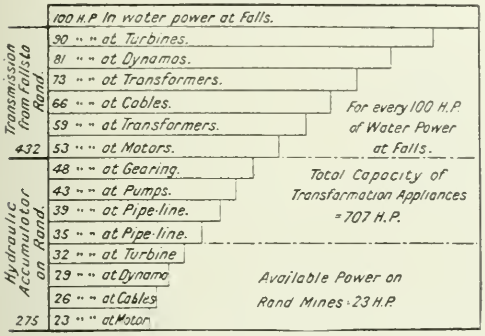
"In my youthful wisdom I looked on the Newcomen engine and water wheel as a rather clumsy and expensive scheme, but in my mature age I ask myself whether, in our anxiety to do everything through the medium of electricity, we do not often propose, and sometimes carry out, more imperfect engineering work.

"In driving the manganese mill the losses due to the indirect method of driving were in the pumps and water wheel; that is to say, there were two tranformations in the transmission. Each transformation, of course, causing a loss of energy. I find in the Victoria Falls scheme that there are no less than fourteen transformations, each representing a loss of energy. The losses are not the same percentage for each transformation, and I shall not attempt to estimate what each individual loss would be. For the sake of illustrating my argument, I will assume a uniform efficiency of

90 per cent.: not a low efficiency for things generally. On this assumption every 100 horsepower taken from the falls will dwindle down to 23 horsepower at the consumer's premises on the Rand mines, and the total power represented by the various appliances employed to produce that result would be 700 horsepower. This is shown clearly on the accompanying diagram. It is true some of the power would be distributed at the sixth stage—see diagram—with a corresponding advantage; but the value of the scheme as a commercial undertaking must be based on the total cost of the whole, plus the working expenses. Leaving out of consideration the working expenses, which would be necessarily very considerable, the great cost of the undertaking, compared with the net result, would in itself make the game not worth the candle. Long distance electric transmission is very interesting, but it is only of practical value when it returns to the investor a fair interest on the money invested.

Power Diagram.

Assumed uniform efficiency at 90%



Illustrating mechanism required and power lost in Transmission and Transformation.

"My object in writing this letter is to point out that the adoption of up-to-date notions, like change in fashions, often leads to expenditure incommensurate with the advantage derived, and I only use the Victoria Falls scheme as an illustration to show how much energy and hard cash one can fritter away by transformations. I do not think that the commercial value of the scheme has had the practical consideration and investigation which should be given to an undertaking for which the public are invited to provide so much money.

"Henry Davey."

A cube of air 31 feet on each side weighs over a ton.

THE USE OF PNEUMATIC TOOLS IN WORKSHOPS*

By Charles Palmer Whitcombe, M.Inst.C.E.

It may perhaps be difficult for those now concerned in the every-day use of pneumatic tools to realize that only about ten years have elapsed since portable pneumatic tools of a suitable design for general use in workshops became readily available in this country, the tools specially referred to being the hammer—for chipping, caulking, and riveting, and the drill—for boring, tapping, reaming, and like purposes. Previously, high-pressure air had been occasionally employed in workshops, but the machines utilized were of a class distinctly different from the hand tools which have in recent years won their way to the front.

INSTALLING A COMPRESSED AIR PLANT.

The main points demanding attention when installing a compressed air plant are:

1. Capacity of air compressor.
2. Method of driving and general design of air compressor.
3. Arrangement and capacity of air mains, receivers, and service pipes.

In fixing the capacity of the compressor a very ample margin should always be allowed, it being quite impossible to accurately foresee all future requirements. The type of machine is frequently determined by the space available, and the method of driving by existing conditions. Steam-driven machines are, where practicable, generally installed in preference to belt-driven. Driving by direct coupling to an electric motor is often adopted, but the interposition of a rope-driven countershaft affords a very effective alternative arrangement of electric drive. For air pressures of 80 pounds per square inch and upwards the use of compound air cylinders and an intercooler will effect an appreciable saving, and where a steam pressure of 150 pounds or more is procurable, compound steam cylinders are advisable.

Air mains should be of liberal diameter, thus affording storage capacity and tending to avoid loss of pressure by friction. Separate receivers should be located near the principal points of consumption; water traps and drip cocks should be provided in convenient positions; all joints and connections should be insured against leakage, occasional tests being desirable. Theoretically, the reheating of compressed air, when the distance traversed is considerable, should be productive of economy; but very little attention seems to have been directed to this matter so far as workshop plants are concerned, the reason being, probably, that a reheater to be fully effective must be placed close to the point at which the air is actually used. This requirement would in most cases prove prohibitive, but not, perhaps, where compressed air is used for operating power hammers, and a test of the results of reheating under such circumstances would certainly prove interesting.

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*Paper read at the Engineering Conference of the Institution of Civil Engineers, June 20, 1907.

RECENT IMPROVEMENTS IN PNEUMATIC TOOLS.

It may be assumed that the distinctive characteristics of the designs of pneumatic hammers and drills which have established their position are fairly well known; no radical changes appear to have been effected during the past few years, but the efforts of designers and manufacturers have been directed, with a considerable measure of success, to improving the construction, economizing the air consumption, and facilitating the operating.

MAINTENANCE OF TOOLS.

Maintenance in the highest state of efficiency is essential to the satisfactory operation of pneumatic tools, and the prompt replacement of a defective part frequently exercises a vital influence on the out-turn capacity of the tool concerned. Such replacement is facilitated by the interchangeability of parts, due to the system of manufacture adopted in the production of these tools. It is usual when large numbers of tools are in constant use to arrange for their periodical examination and test by selected workmen, and it will be at once recognized that the general adoption of this practice might be expected to produce very beneficial results.

COMPARATIVE SPEED CAPABILITIES.

From actual results the following comparisons of speeds of out-turn as compared with hand work have been compiled; it is not claimed that these speeds are applicable to all classes of work, but that they can be generally attained and sometimes even exceeded:

Description	——Speeds——	
of work.	By hand.	By pneumatic tool.
Heavy chipping.	1	2 to 4
Caulking	1	3 to 4
Drilling	1	3 to 4
Rimering	1	4 to 6
Riveting	1 (3 men)	1½ to 2½ (2 men)

ECONOMICAL RESULTS.

The economical results achieved, so far as piece-work rates alone are concerned, are not nearly proportionate to the higher of the speeds enumerated above, but the reduced rates which have formed the subject of agreement between employers and employed, enable the latter to earn higher wages in a given time, and the increased rapidity of out-turn constitutes an important item for the employers' consideration when comparing results with hand work. The following figures show, approximately, the reductions in piece-work rates effected by the use of pneumatic tools in the United Kingdom:

Description of work.	Percentage off hand-labor rates.
Chipping	35 to 50
Caulking	35 to 55
Drilling	40 to 60
Rimering	50 to 75
Riveting	30 to 50

Figures recently prepared by a leading firm for their own information showed that a weekly saving of more than £2 was being effected in wages for every pound sterling of running cost of the pneumatic plant, the latter including interest on capital outlay, depreciation, power charges, maintenance and repairs. The number of tools owned by the firm concerned exceeds 80, and their compressing plant has a capacity of 1,500 cubic feet of free air per minute.

Reductions in piece-work rates in Germany are reported to vary as follows:

Description of work.	Percentage off hand-labor rates.
Chipping and caulking	35 to 65
Drilling	50 to 80
Riveting	35 to 60

GENERAL REMARKS.

The advantages derivable from the use of modern portable pneumatic tools for special purposes are now, it is considered, admitted with practical unanimity; some of those who were among the most determined opponents of such tools are to-day found in the ranks of their warmest advocates. The demand for these tools has steadily increased year by year, though not so rapidly in the United Kingdom as in the United States and in Germany; this difference has been due mainly to the opposition experienced here to the use of portable riveting tools, an opposition which it is understood has recently been to a large extent overcome, and in that case a continuation of the growth of development in this country may be reasonably predicted.

TRADE PUBLICATIONS.

Sullivan Mining Hoists.—Sullivan Machinery Company, Chicago.—24 pages, 6x9 inches, 26 illustrations. Illustrates and briefly describes heavy hoisting plants built by this company for deep mine service.

A Quarter of a Century Building High Grade Steam Engines and Nothing Else. Ball Engine Co., Erie, Pa.; 18 pages, 6½x6 inches, folded to 6x3¼ inches; 14 half-tones. Describes the various styles of engines built by the company.

Bantam Anti-Friction Booster, No. 1, Bantam, Conn.—4 pages, 13x21 inches, yellow in color. Inside pages give information about Bantam ball bearings. Outside astonishing and indescribable, and what might be expected from the man responsible for it. The outside will be read whether the inside is or not.

The Temple Ingersoll Electric Air Rock Drill.—Form 20, Ingersoll-Rand Co., New York; 60 pages, 6x9 inch; profusely illustrated. The drill is fully described and all its details are shown. The half-tones show the drill in operation under various and widely different conditions, and records of performance are given which show most remarkable results, especially in power cost for operating.

The roof and walls of the New York Fourth Avenue tunnel from 34th to 40th streets, which is traversed by surface cars, were recently being whitewashed by the pneumatic spraying system. A car came along and as a result of something wrong with the apparatus the nozzle was directed right at the car with the whitewash in full flow. The motorman stopped his car and was completely drenched by the stream. Then he started slowly and the fifteen passengers on board all received a similar coating.

The regular monthly meeting of the American Society of Mechanical Engineers on October 8 will be addressed by Prof. John P. Jackson, of the Pennsylvania State College, upon "The Relation of the College Technical Course to the Apprenticeship Course in Industrial Establishments." Prof. Dugald C. Jackson, of the Massachusetts Institute of Technology, and president of the Society for the Promotion of Engineering Education, and Dr. Henry Pritchett, president of the Carnegie Foundation and of the American Society for the Promotion of Industrial Education, will address the meeting. On November 11 Charles R. Pratt will read a paper on the elevators of the new Singer and Metropolitan Life Insurance buildings. The gas-engine and foundry practice will be the leading topics of the annual meeting in December.

The Vredenburg Company, recently organized, whose manager is Mr. Clarence Vredenburg, the only editor and manager of *Engineering World* up to its recent sale, is established at 1332 Monadnock Block, Chicago. It will be engaged in a consulting practice in engineering and general technical advertising.

Tantalum is so hard that the only effect produced by a diamond drill, worked day and night for three days on a sheet of the substance one-twenty-fifth of an inch thick, with a speed of 5,000 revolutions per minute, was a slight dent in the sheet and the wearing out of the diamond.—*Mines and Mining, Denver.*

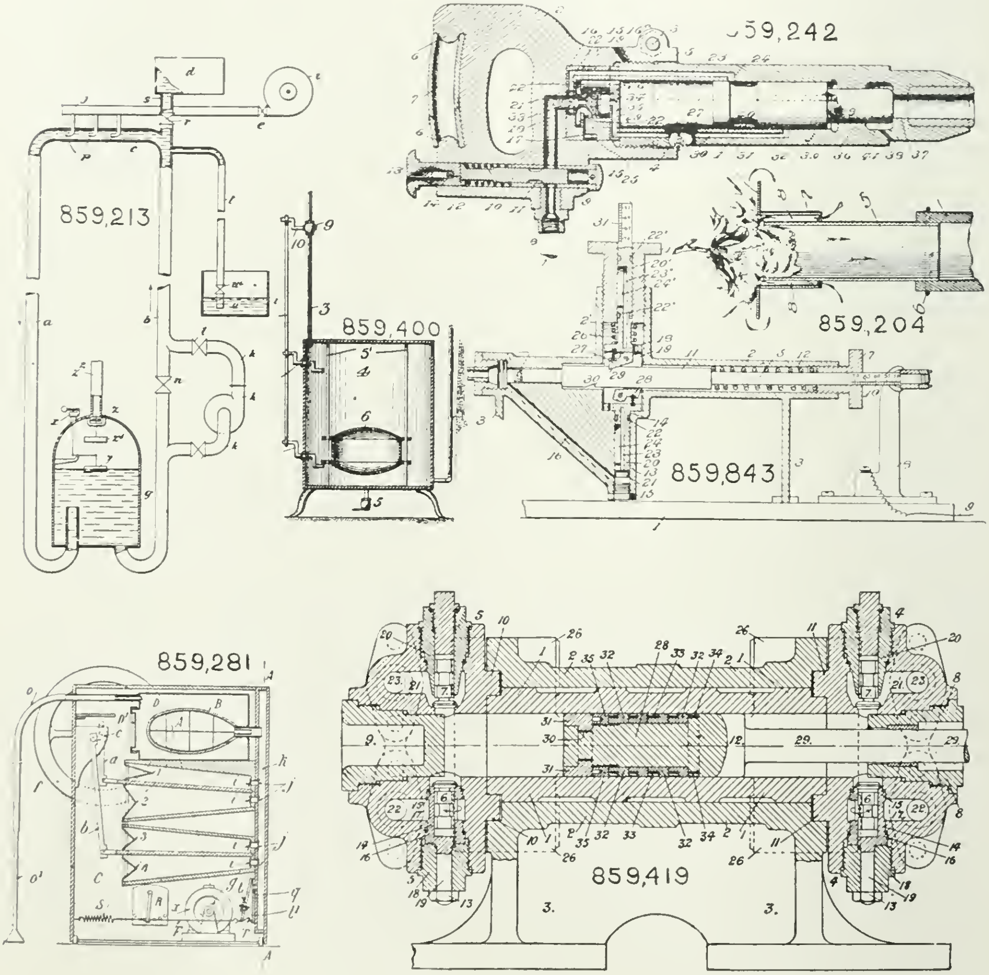
In the erection of the superstructure of the Peterborough hydraulic lock on the Trent Canal, a pneumatic wrench was used for screwing up nuts on bolts up to 1⅝ inches in the large presses and rams. The machine consisted essentially of an oscillating, double-acting air cylinder, the piston of which rotated a box wrench through the medium of a ratchet. The machine weighed about 70 pounds, was handled by two men and did the work of twenty-five in the same time and in a more satisfactory manner.

Bulk for bulk, alcohol will not develop as much power as gasoline but it possesses other decided advantages in the matter of storage. If a can of gasoline, and especially a can only partly filled, be left open near a flame it is quite likely to explode by ignition, which could never occur with alcohol. Water is useless to quench burning gasoline, serving only to spread the flame by floating the liquid, while alcohol mixes with water in all proportions and when so diluted becomes non-inflammable. The safety of alcohol must lead to its adoption for that particular alone in many lines of service, as, for instance, in submarine boats and other hazardous places from which there is no ready escape.

"*The Art of Cutting Metals*," by Frederick W. Taylor, M. E., Sc. D., which was the presidential address presented at the last annual meeting of The American Society of Mechanical Engineers, has been reprinted and bound in cloth by the Society; price, $3.00. This or any other publication of the Society may be had by addressing the Secretary, 29 West 39th Street, New York. It is not necessary to send orders through members. None of the publications of The American Society of Mechanical Engineers is copyrighted.

CHANNELERS AT PANAMA.

The Isthmian Canal Commission has decided that the walls of the canal, where it passes through rock, shall be channeled. This includes most of the "wet prism" in the Culebra Division, nine miles long, and also the walls of the locks at La Boca and Mira Flores. The wall formed by the channeler is cut exactly to the surveyed line. It is announced by the Sullivan Machinery Company, Chicago, that it has been awarded a contract for 24 Class Y 8 channelers for this work. This machine is similar to, but larger and more powerful than those of Class Y of the same company.



PNEUMATIC PATENTS JULY 9.

LATEST U. S. PATENTS.

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JULY 9.

859,204. PICKER NOZZLE FOR PNEUMATIC COTTON-PICKING MACHINES. WOODBURY K. DONA, Westbrook, Me.

859,213. APPARATUS FOR COMPRESSING AIR OR OTHER ELASTIC FLUID FOR THE PRODUCTION OF MOTIVE POWER. JOHN GILL, Edinburgh, Scotland.

859,242. PNEUMATIC TOOL. SAMUEL OLDHAM, Philadelphia, Pa.

859,281. MACHINE FOR REMOVING DUST FROM CARPETS BY SUCTION. JULIUS R. BLUM, Paris, France.

859,400. WATER ELEVATOR. EDWARD G. MARTIN and JOHN H. HAKE, Tyler, Texas.

859,419. GAS COMPRESSOR. WALTER H. WEBB, WILLIAM G. BRETTELL and ALEXANDER J. ADAMSON, Liverpool, England.

859,843. CONTROLLER FOR PNEUMATIC COMPRESSORS. LEBBEUS H. ROGERS, New York.

JULY 16.

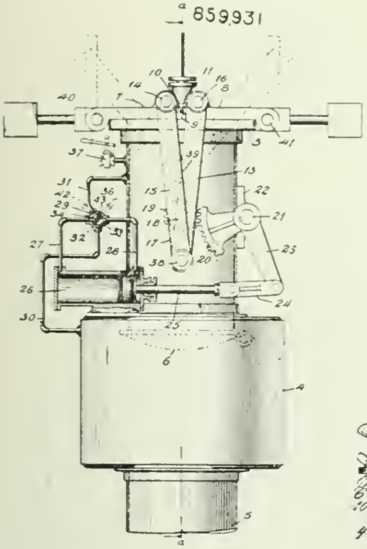
859,914. APPARATUS FOR CLEANING CARPETS. SIEGFRIED BUDER, Halensee, Germany.

859,915. PNEUMATIC SWEEPER. SIEGFRIED BUDER, Halensee, Germany.

859,920. REDUCING VALVE. HARRY F. CUNNING, Roanoke, Va.

859,931. AIR-LOCK FOR CAISSONS. CHARLES I. EARLL, assignor to John Monks & Sons, New York.

860,208. ELECTRO-PNEUMATIC TRACK CHANNELER. ARTHUR H. GIBSON, Easton, Pa., assignor to Ingersoll-Rand Company, New York.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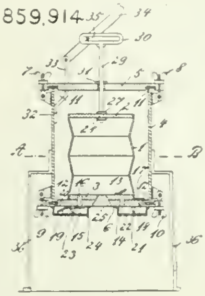
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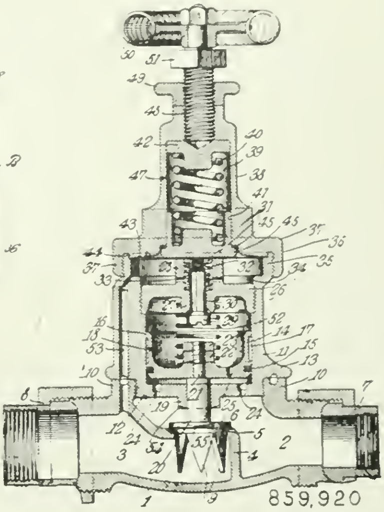
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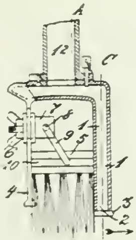
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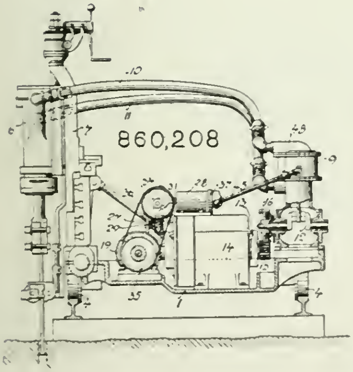
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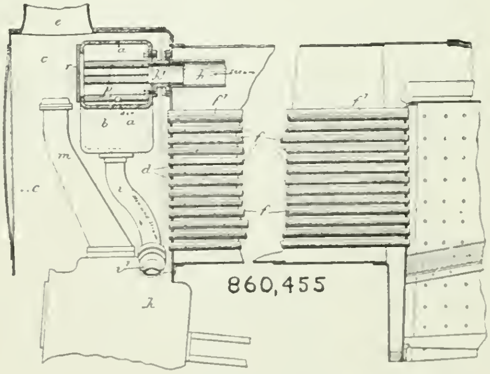

860,455

PNEUMATIC PATENTS JULY 16.

860,455. LOCOMOTIVE OR OTHER ENGINE USING A MIXTURE OF AIR AND STEAM AS A MOTOR FLUID. EDWARD FIELD, London, England.

860,595. ELASTIC FLUID TURBINE. CHARLES G. CURTIS, New York, assignor to General Electric Company.

JULY 23.

860,622. PNEUMATIC TRUCK. ALEXANDER R. BANNERMAN, WILLIAM SUMMERTON, and DONALD MACDONALD, Winnipeg, Manitoba, Canada.

860,786. SUCTION DEVICE FOR DUST-REMOVING PNEUMATIC MACHINES. JULES R. BLUM, Paris, France.

860,826. AIR-COMPRESSOR. WILLIAM REAVELL, Ipswich, England.

860,842. PNEUMATIC FIRE-ALARM. WILLARD WADSWORTH, Plainfield, N. J.

860,851. PNEUMATIC FOR AUTOPNEUMATIC PIANOS. JAMES CARRUTHERS, Newark, N. J.

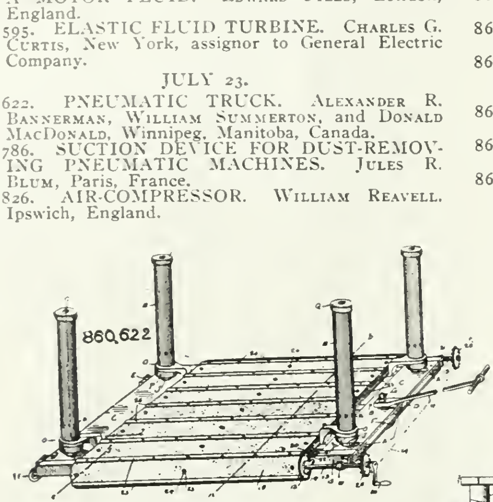
860,949. AIR-BRAKE SYSTEM. AUGUSTUS A. ST. CLAIR, Indianapolis, Ind.

860,947. PNEUMATIC-DESPATCH CARRIER. JOHN W. UPP and WILLIAM O. WAKEFIELD, Schenectady, N. Y.

860,986. ELEVATOR AIR-BRAKE SYSTEM. ALFRED H. MEECH, Chatham, N. Y.

861,038. AUTOMATIC GAS-REGULATING VALVE. BENJAMIN M. LEWIS, Reno, Nev.

861,193. VACUUM-MACHINE. PHILLIP H. McCABE and ALPHONSE J. LAVOIE, Toronto, Ontario, Canada.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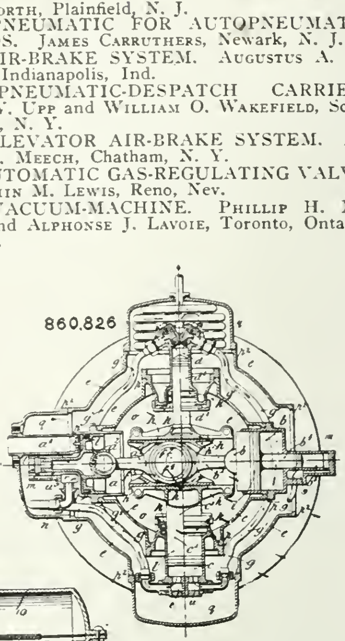
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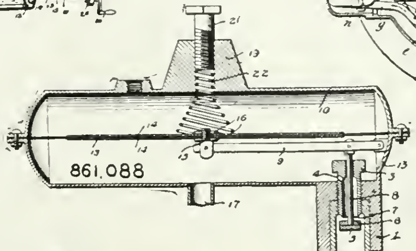
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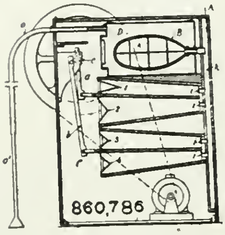
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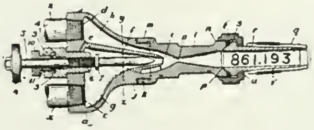
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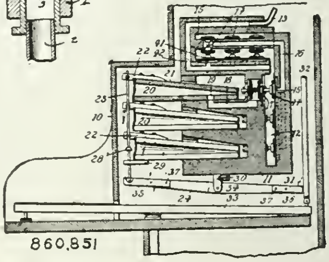
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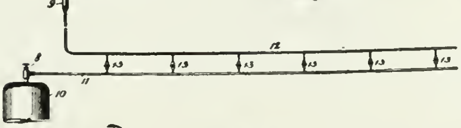

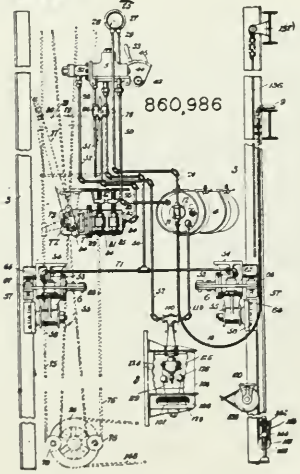
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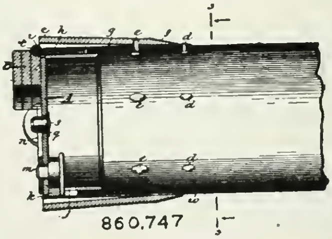
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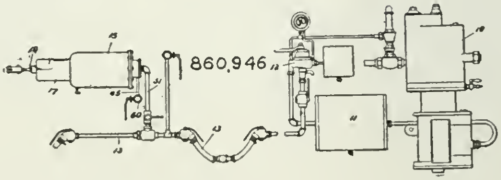
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PNEUMATIC PATENTS, JULY 23.

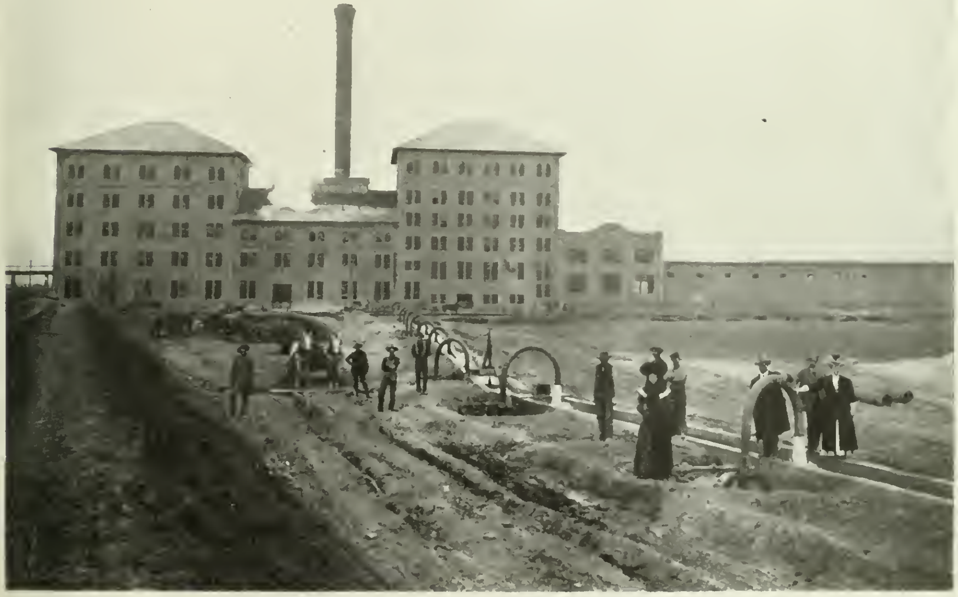
COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. XII OCTOBER, 1907 No. 8

A TYPICAL POHLE AIR LIFT

The half-tone shows an interesting and highly successful air lift installation at Garden City, Kansas, the information concerning it being furnished us by The Stearns-Roger Manufacturing Company, Denver, Colo.



THE POHLE AIR LIFT AT A SUGAR FACTORY.

The building shown is a beet-sugar factory. The working season is from the beginning of September to about New Year's, and during that time the water consumption is about 4,000,000 gallons per twenty-four hours.

There is a strong underflow in a stratum of gravel underlying the entire section at Garden City and extending on both sides of the Arkansas River. The sand and gravel is about 45 feet thick from the surface down; then comes the clay. The water flows through this loose gravel parallel with the river. It is of course on top of the clay stratum.

A duplex Type X-1 Imperial compressor, 16 and 25 by 20 inches, was placed in the factory on the main floor, about where the line of wells shows as coming against the factory wall in the half-tone. Then twenty-five wells were sunk, practically in a straight line from the factory toward the river. The wells are 40 feet apart and each well is 60 feet deep; running 40 feet to the clay, and then the balance in the clay, so as to get sufficient submergence for the Pohle air lift system.

In sinking the wells 16 inch wrought iron pipe was used, weighting the top of the pipe and taking the gravel from the interior by means of the ordinary sand pump, the pipe gradually sinking until the depth of 60 feet was reached. A perforated galvanized-iron casing, about 20 gauge, was placed inside of the standard wrought-iron pipe used in the sinking and then the wrought-iron pipe was pulled out, allowing the hole to cave to the galvanized casing. Inside the casing the induction pipe of 6-inch standard wrought-iron was placed, this extending to a depth of about 40 feet from the surface, and into this the 2-inch air pipe was turned with a Pohle endpiece upon it. The delivery, as noted in the photograph, is made by 6-inch 180° bends, discharging into a common conduit.

This concrete conduit was built on the ground on wooden frames, with a grade of about 2 inches in 100 feet. It is 3 feet by 2 feet 6 inches, with a practically semi-circular bottom and open at the top, as we find very little trouble from freezing, never having any very cold weather at Garden City.

The wells are worked by the air pipe which starts from the factory. The first fifteen wells are on an 8-inch air pipe, the next five on a 5-inch, the next five on another 5-inch, and the next five on a third 5-inch pipe. We have, therefore, four groups of wells, three of five each and one of fifteen, fed by independent pipes from the receiver. This enables us to cut the air off at the factory compressor, if we choose, and to alternate the wells.

The conduit delivers into a concrete tank sunk into the ground. It is 30 by 20 feet and 10 feet deep, the suctions of the factory pumps taking from this. The tank is more for a sand trap or settler than for storage, as for that purpose the capacity required would be prohibitive.

The delivery of the wells could not be computed, nor even very approximately guessed, in advance, so, to make sure, twenty-five were sunk, for the reason that when the sugar campaign is begun operations cannot be stopped or interfered with without serious loss.

It was actually found that eight wells would give the requisite supply of 4,000,000 gallons per twenty-four hours. The natural water level is 12 feet from the surface, and as the pumping starts in September, this level gradually recedes until in December it reaches the lowest point, 25 feet from the surface.

SCIENCE OF THE AIR IN RELATION TO VENTILATION*

By N. W. Hoskins.

Air is simply a mechanical mixture of certain gases which exist in a free state, and vary within very narrow limits, except in the case of aqueous vapor. One hundred volumes of pure air consist of:

Oxygen	20.66
Atmospheric nitrogen	77.90
Carbon dioxide	.04
Aqueous vapor	1.40

Ammonia, argon, ozone and other gases are sometimes present in small and variable proportions.

Oxygen is the most important constituent of the air, and the quantity present in pure air in any part of the world varies very slightly. It is only under exceptional circumstances that it exceeds 21 per cent or falls below 20 per cent. In its pure state it is a colorless gas without taste or smell, slightly heavier than air, having a specific gravity of 16 (air being 14.4) compared with hydrogen as unity, and it is a vigorous supporter of combustion.

Nitrogen appears to act as a diluter of the stronger gases, but it doubtless has its special functions higher than this. A lighted candle plunged into a jar of nitrogen is immediately extinguished. It is a colorless, inert gas, without taste or smell, and will not support animal life or combustion. It is not poisonous, and animals enclosed in a space containing nitrogen alone would die of suffocation from the want of oxygen. Carbon dioxide (CO_2), although present in such small quantities compared with the gases dealt with, is one of great importance with respect to ventilation. It cannot be considered as an impurity, as the most pure air always contains a small proportion, seldom less than 0.03 per cent. Pure CO_2, even up to 0.1 per cent (one part in 1,000 parts of air), is not harmful, and in mineral water factories the air is often found to contain this high percentage without any harmful effects on the work-people employed. A large quantity of this gas is given off from our bodies direct, and by respiration; it is also one of the products of combustion.

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*Abstracted from proceedings of Royal Sanitary Institute, London.

Absolutely dry air is never found in Nature, and aqueous vapor must, therefore, be considered as an essential ingredient of atmospheric air. It is also a very important constituent, which varies very considerably under different conditions of temperature and pressure. Moisture is being continually added to the air by evaporation from the water on the earth's surface, and also by respiration and combustion.

[The air also is constantly giving up its moisture under certain conditions, and one of its most important functions is the conveyance and distribution of moisture over the surface of the earth.—*Ed. C. A.*]

The higher the temperature, the larger quantity of invisible moisture the air can retain. Air is said to be saturated when it contains the maximum quantity of vapor it is capable of holding. This matter relating to moisture is frequently overlooked in the ventilating of buildings, and especially so when the heating of a building is designed in conjunction with the ventilating. Dry air is a bad conductor of heat, and therefore tends to prevent the escape of warmth from the body. In a room in which the air has a humidity of 30 per cent and a temperature of 70° Fahr., a person will feel perceptibly colder than in a room the air of which has 60 degrees of humidity and a temperature of 60° Fahr. By adding moisture, therefore, a room may at times be brought under more comfortable conditions at a less expense than by the consumption of fuel.

TABLE OF SATURATION UNDER DIFFERENT TEMPERATURES. BAROMETER 30 INCHES.

Temp. F.°	Weight of vapor in grains per cubic foot.	Temp. F.°	Weight of vapor in grains per cubic foot.
30	1.97	65	6.81
32	2.13	70	8.01
35	2.39	75	9.39
40	2.86	80	10.98
45	3.44	85	12.78
50	4.10	90	14.85
55	4.87	95	17.18
60	5.77	100	19.84

A trace of ammonia is usually found in town air, and is probably entirely due to the decay of nitrogenous animal and vegetable substances. It is a transparent gas with a very pungent peculiar odor; it will not support combustion, and is only feebly combustible. Ammonia is dissolved by water with avidity, a pint of water at 32° Fahr. absorbing as much as 23 cubic feet of the gas. Probably, therefore, the whole of the ammonia is cleared from the air during a shower of rain.

Ozone is a colorless gas of peculiarly unpleasant odor. Outside of the laboratory it is found only in open country and sea air. It is chiefly remarkable on account of its oxidizing power, and plays an important part in removing organic impurities from the air. Ozone is really a condensed form of oxygen, one molecule of the gas containing three atoms, whereas one molecule of oxygen contains only two atoms. Air charged with ozone has an irritating effect on the respiratory organs. The gas may be prepared experimentally by passing an electric current through pure dry oxygen. Little is known of the circumstances under which it is produced in nature. It is, however, intimately related with the development of atmospheric electricity.

The air of buildings and confined spaces is rendered impure by extracting the oxygen, which supports animal life and combustion, and by adding to it CO_2 and other deleterious substances. Large quantities of oxygen are required to support animal life, and in return CO_2, with other impurities, are continually being thrown off.

Although gases are of different densities, they have the power, when brought in contact, of intimately mixing together. This important property is termed the diffusion of gases, and has an important bearing upon the air of buildings, which is kept pure to a large extent by diffusion. Gases diffuse in the inverse ratio of the square root of their densities. The lighter the gas, the more quickly does it diffuse. Diffusion of gases takes place also, to a less extent, without being in actual contact. The materials used for constructing the walls of buildings permit the air to pass through more or less rapidly to diffuse with the outer air. The spontaneous mixing of gases is caused by their particles being always in rapid motion. A very small quantity of coal gas is soon detected in a building, owing to the power of diffusion. Gaseous impurities which leave our bodies at a higher temperature than that of the surrounding air quickly diffuse and become diluted, but in crowded buildings, and even in dense crowds in the open air, the impurities are often produced at a greater speed than the rate of diffusion.

In dealing with the density of gases, we must not overlook the importance of the varying changes brought about by moisture. The density of the air varies with respect to the amount of moisture it contains. The density of a mixture of gases will be equal to the mean of its constituents, and the density of air is superior to that of water vapor in the ratio of 14.4 : 9. Therefore, *moist air will be lighter,* bulk for bulk, according to its hygrometric condition, and consequently *moist air tends to rise as warm air does.*

The old standard of purity, as laid down by Dr. De Chaumont, is that the air of a room should not contain more than 0.02 per cent of CO_2 in excess of the external atmosphere. This standard is advocated by most authorities, although considered by some to be rather stringent. On an average, we breathe at the rate of sixteen respirations a minute, inhaling about 30 cubic inches at each breath, therefore $(16 \times 60 \times 30 \div 1728) = 16$ cubic feet of air per hour is exhaled, of which 4 per cent, or 0.6 cubic feet, is CO_2. To maintain Dr. De Chaumont's standard of purity each person must be supplied with 3,000 cubic feet of fresh air per hour, and if the air of a room is completely changed three times in one hour, each person should be supplied with 1,000 cubic feet of air space. Dr. Galton says that 1.5 per cent of CO_2 present in the air will produce headache, and as anything below 0.1 per cent appears to have no detrimental effect on health, it would appear that the percentage of permissible impurity might well be raised to 0.1 per cent; this would bring the practice of the engineer more in keeping with the medical theory.

There is no simple and reliable test for determining the amount of organic impurities which may be present in the air. The quantity of carbon dioxide in a given volume of air may be ascertained by several methods, and as this gas bears a constant relation to the amount of organic impurities, it is usually taken as an indicator. It is well known that the air of an unventilated room which has been occupied by several persons for a considerable time will have a peculiarly unpleasant odor, which is due to the organic matters given off from the lungs and bodies. The following is a method sometimes adopted for estimating the amount of CO_2 in the air: Collect samples of the air for testing in four bottles, having a capacity of 4, 8, 16 and 32 ounces, respectively. The bottles must be clean and dry, and provided with rubber stoppers. A 1-ounce bottle of fresh lime-water is now carefully poured into each of the four samples, and the stoppers replaced. Agitate the lime-water for about three minutes, and observe the change in color of the lime-water added in each case. Should the lime-water in all four bottles show a milky appearance, it indicates that the samples contain above 2 per cent of CO_2. Should the liquid in the three larger bottles become milky, and the 4-ounce bottle remain clear, the sample contains approximately 1.4 per cent. A milky tinge in the 16-ounce and 32-ounce bottles only indicates 1 per cent, and should the liquid in the 32-ounce bottle only appear milky, the amount of CO_2 in the sample would be 0.06 per cent. No trace of color in any of the four bottles would indicate that the air was pure.

HOW PNEUMATIC TIRES DESTROY THE ROADS

A writer in *The Engineer*, London, writes as follows concerning the destructive action of the pneumatic tires of heavy automobiles:

"Living as I do close to the main road from Chichester to Worthing, I had ample opportunity of watching the action of fast and large cars last year during Goodwood week. The large fast cars might be said to be followed by a rain of small stones or coarse sand, and by the evening of Cup Day—Thursday—*the road was more like a sea beach than a main road.* I frequently examined a piece of road after the passage of several large cars, and I invariably found that, whereas the road was compressed and the stones crushed down by a farm cart, with a motor car the stones were lifted, in some cases to a considerable depth.

"The action of a pneumatic tired wheel takes two forms: (*a*) The load on the wheel tends to bed—*i. e.,* to press down a stone more firmly. The maximum load cannot, however, be applied more than momentarily owing to the shape of the wheel, and with fast-running cars, the pressure being applied for such a short time, the stone resists movement by its inertia. (*b*) Owing to the compression of the tire, the tire can act as a 'sucker,' and, therefore, clings to the stone before action (*a*) is at its maximum, and the stone, if small, is rolled out of its bed by its connection with a moving wheel and either thrown off behind or left in place as a 'loose' stone. Unless the stone is held in place by an active force, such as being keyed in with others, or being made practically *encastré* with cement nothing will stand under fast-running pneumatic-tired wheels but heavy blocks of stone. A floated surface to an underbed of rough concrete will be liable to destruction by 'rolling out' in the same way that two metal plates soldered together can be separated by rolling out—*i. e.*, by stretching one plate unequally to the other. Ultimate separation is certain in course of time. The time required depends only on the quality of workmanship and solder.

Holding Up

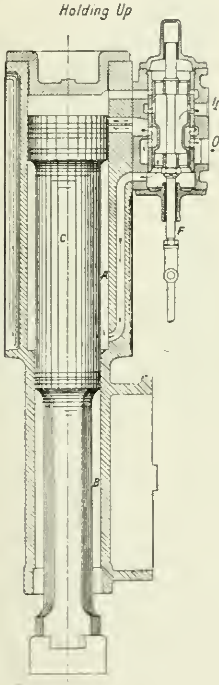

FIG. 1.

Striking Ordinary Blow

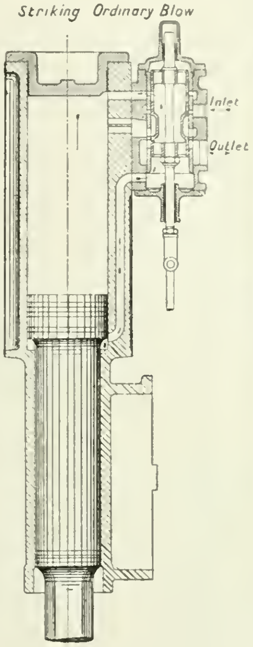

FIG. 2.

Striking Dead Blow

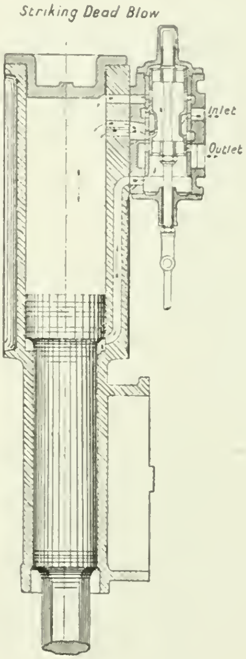

FIG. 3.

COMPOUND PNEUMATIC HAMMER

Although recent years have witnessed a great extension in the employment of pneumatic pressure in engineering workshops, for heavy hammer work such as is met with in large smiths' shops for forging operations, the steam hammer has not been superseded to any very considerable extent. The use of high air pressure for the operation of hand tools of the light percussive type is tending to familiarize works managers with the cleanliness and the "handiness" of pneumatic power which must end in a great development in its uses. In 1903, after much experimenting, Messrs. Pilkington evolved a compound-pneumatic hammer, which showed a considerable economy in the consumption of air compared with those of the high-pressure type in which separate charges of air are used for raising the tup and for striking the blow. The latter system involved the application of air under high pressure on a small piston in the lower of two vertical cylinders to strike the blow, the air after doing its work being then exhausted to a low-pressure receiver which was maintained at 30-40 pounds pressure from the first stage of a compressor. The low-pressure air thus bottled up was next admitted under a large piston to raise the tup, and to expel the air from the lower cylinder. This cycle necessitated the lower cylinder and stuffing-box being split on the longitudinal center line, which was found objectionable from a constructional point of view, and involved the use of an inaccessible stuffing-box round the rod between the lifting and striking pistons. Moreover, breakages of the piston rod due to the weight of the large piston setting up stresses in the rod at the same moment of impact were not unknown. We give a sectional illustration of this older type of hammer in Figure 4, from which these points will be seen, and it will also be observed that the air was exhausted to the atmosphere at considerable pressure, meaning a loss of residual energy which the firm has now found a means of overcoming, as will be seen from the accompanying illustrations and dia-

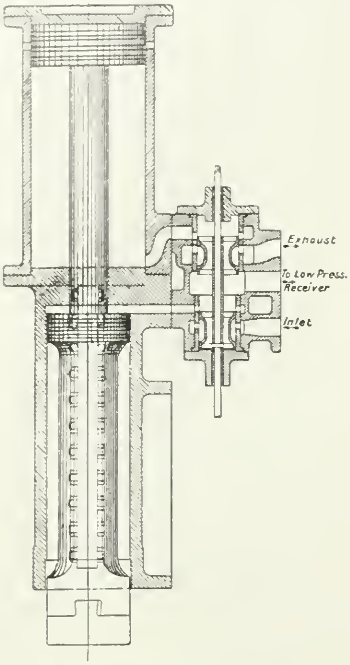

FIG. 4. OLD TYPE OF HAMMER.

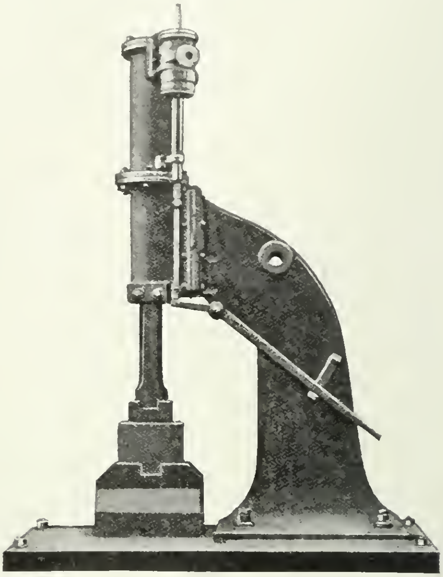

FIG. 5. N. S. K. PNEUMATIC HAMMER.

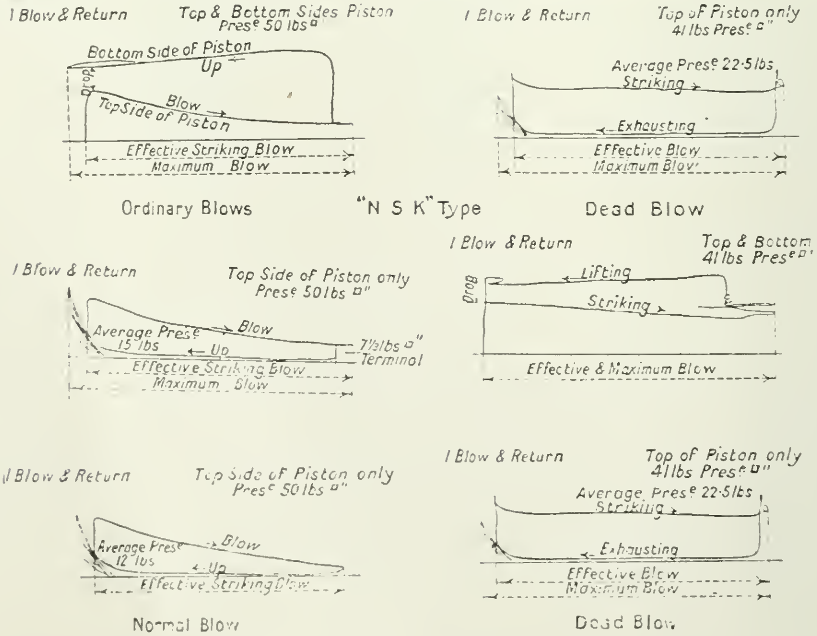

FIG. 6. INDICATOR DIAGRAMS FROM COMPOUND AIR HAMMER.

grams relating to the new "N. S. K." compound hammer.

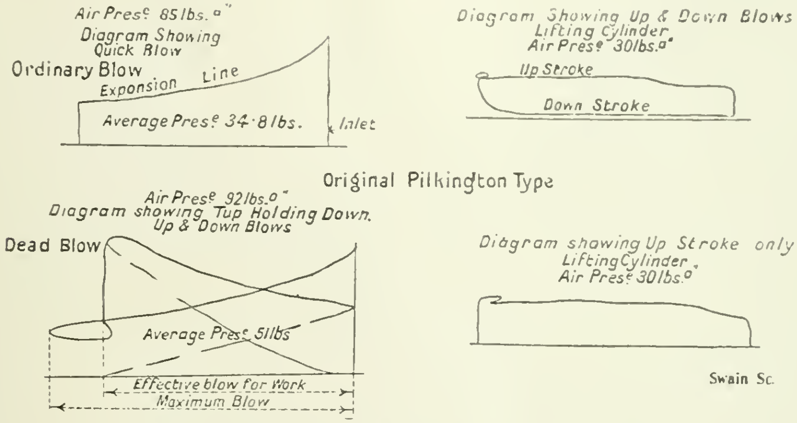

FIG. 7. INDICATOR DIAGRAMS FROM PILKINGTON HAMMER.

A general view of one of a batch of seventeen of these hammers, which the firm of Peter Pilkington, Limited, Bamber Bridge, is building for Messrs. Harland & Wolff, is shown in Figure 5, and in Figures 1, 2 and 3 are given sectional illustrations of the hammer, showing the tup and valves in their different relative positions. Figure 1 shows the holding-up position; Figure 2, the position of parts when striking an ordinary blow; and Figure 3, the positions of the valve and tup when making a dead blow. The tup, piston and jaws for securing the pallett are forged from a solid steel ingot, and the section of the tup is uniform throughout, while the cylindrical portion of the tup is almost entirely contained in the guiding cylinder when the blow is struck. As will be seen from the sectional drawings, there are two cylinders, A and B, the upper one, A, being the working cylinder, and the lower being used as the guide only. The upper end, C, of the tup working in the uppermost cylinder, A, is in the form of a differential piston. High-pressure air is admitted in the direction of the arrows, Figure 1, when raising the tup only, and this same air on being exhausted is expanded on the top side of the piston for striking ordinary blows, the path of the air being shown in Figure 2. If, however, a very heavy or stamping blow be required the operator can utilize the full air pressure in the compressor on the top of the piston in addition to that discharged from beneath the piston, the valves being constructed with two sets of ports, as shown.

The construction of the hammers is very simple, the operating valve being cylindrical, of cast iron, with suitable ports, working in a cast-iron liner. The valve is controlled by a hand lever actuating the valve spindle, F, in the same manner as that of a steam hammer, and its action is very sensitive. We have witnessed the operation of a N. S. K. hammer that has been in use for about fifteen months, the tup of which was arrested in any desired position, showing no leakage. A brief study of the sectional drawings will serve to illustrate the fact that owing to the difference in the areas of the annular ring below the piston,

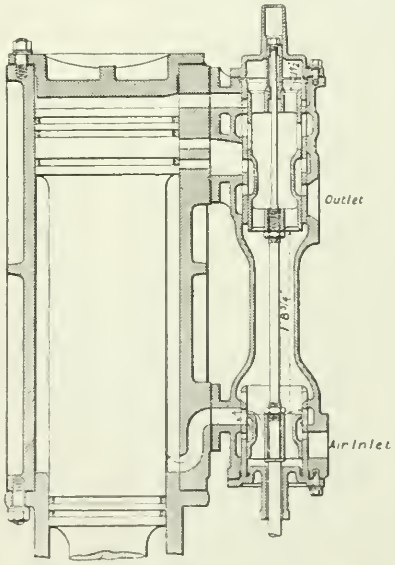

FIG. 8. CHEST FOR LARGE HAMMER.

Ordinary Blows.

	Original Pilkington type.		"N.S.K." type.	
	Formula.	Data.	Formula	Data.
Weight of tup..	7 cwt. 1 qr. 12 lb. =	824 lb.	8 cwt. 2 qr. × 112 lb =	952 lb.
Ft.-lbs. of energy due to tup falling 2ft. ..	824	1648	952 × 2 =	1904 lb.
Area of striking oylinder	Net sq. in.	58 sq. in.	Net sq. in.	95 sq. in.
Working pressure per square inch	Gauge	85 lb. per sq. in	Gauge	50 lb. per sq in.
Average pressure acting on striking piston	—	34·8 lb. per sq. in.	—	15 lb. per sq. in.
Ft.-lbs. of energy imparted to tup by air pressure	area pres. ft. 58 × 34·8 × 2 =	4036	area pres. ft. 95 × 15 × 2 =	2850
Total energy imparted to tup by air pressure and gravity	1648 + 4036 =	5684 ft.-lb.	1904 + 2850 =	4754 ft.-lb.
Velocity of tup at point of contact ..	$\frac{5684}{824} = 6{\cdot}89 = \frac{V^2}{64{\cdot}4}$ V = $\sqrt{6{\cdot}89 \times 64{\cdot}4}$ = 21·06ft. per sec.		$\frac{4754}{952} = 4{\cdot}991 = \frac{V^2}{64{\cdot}4}$ V = $\sqrt{64{\cdot}4 \times 4{\cdot}991}$ = 17·9ft. per sec.	
Terminal pressure per square inch	Gauge	24 lb. per sq. in.	Gauge	7½ lb. per sq. in.
Cubic feet of free air discharged from low-pressure cylinder	$\frac{117{\cdot}6 \times 2 \times 39}{144 \times 15}$ =	4·205	$\frac{143{\cdot}14 \times 22\frac{1}{2} \times 2}{144 \times 15}$ =	3
Horse-power required to give 100 blows per minute	4·2 × 20 =	84	11·9 × 3 =	35·7
Horse-power corrected for equal work ..	—	84	$\frac{35{\cdot}7 \times 5684}{4754}$ =	42·66
Excess of power required by old system to do equal work as compared with new	$\frac{84}{42{\cdot}66}$ =	96·9 per cent.	—	—

FIG, 9. TABLE OF TESTS OF COMPOUND HAMMERS—ORDINARY BLOWS.

and that of the top of the piston, the air which has been used to raise the tup will be expanded to nearly four times its initial volume, and will be finally exhausted at about atmospheric pressure by the raising of the tup again.

We are enabled to give in tabular form some interesting details of tests made with the N. S. K. hammer, and the older Pilkington hammer, which show very clearly the saving in power effected by the former. In the first

Dead Blows.

	Original Pilkington type.		"N S.K." type.	
	Formula	Data.	Formula.	Data.
Weight of tup..	7 cwt. 1 qr. 12 lb. =	824 lb.	8 cwt. 2 qr. × 112 lb. =	952 lb.
Ft.-lbs. of energy due to tup falling 2ft. ..	824 × 2 =	1648	952 × 2 =	1904
Area of striking oylinder	Net sq. in.	58 sq. in.	Net sq. in.	95 sq. in.
Working pressure per square inch	Gauge	92 lb.	Gauge	41 lb.
Average pressure acting on striking piston	—	51 lb. per sq. in.	—	22·5 lb. per sq. in
Ft.-lbs. of energy imparted to tup by air pressure	area pres. ft. 58 × 51 × 2 =	5916	area pres. ft. 95 × 22½ × 2 =	4275
Total energy imparted to tup by air pressure and gravity	1648 + 5916 =	7564 ft.-lb.	1904 + 4275 =	6179 ft.-lb.
Velocity of tup at point of contact ..	$\frac{7564}{824} = 9{\cdot}179 = \frac{V^2}{64{\cdot}4}$ V = $\sqrt{9{\cdot}179 \times 64{\cdot}4}$ = 24·3ft. per sec.		$\frac{6179}{952} = 6{\cdot}49 = \frac{V^2}{64{\cdot}4}$ V = $\sqrt{6{\cdot}49 \times 64{\cdot}4}$ = 20·4ft. per sec.	
Terroinal pressure per square iuch	Gauge	28 lb.	Gauge	22·5 lb.
Cubic feet of free air discharged from low-pressure cylinder	$\frac{117{\cdot}6 \times 2 \times 41}{144 \times 15}$ =	4·46	$\frac{143{\cdot}14 \times 37\frac{1}{2} \times 2}{144 \times 15}$ =	5
Horse-power required to give 100 blows per minute	4·46 × 21 =	93·6	5 × 10·6 =	53
Horse-power corrected for equal work ..		93·6	$\frac{53 \times 7564}{6179}$ =	64·8
Excess of power required by old system to do equal work as compared with new	$\frac{93{\cdot}6}{64{\cdot}8}$	44·4 per cent.	—	—

FIG. 10. TABLE OF TESTS OF COMPOUND HAMMERS—DEAD BLOWS.

table the figures are given for ordinary blows, and it will be noticed that the hammers under test are of different capacities. It will be observed that the terminal pressure of the new hammer is only 7½ pounds per square inch, compared with 24 pounds in the case of the older form, and also that the saving of power due to the further utilization of the air in the acceleration of the tup, when corrected to represent hammers of equal capacity, is nearly one-half. In the second table, for dead blows, it will be observed, notwithstanding the admission of live air on top of the piston, in addition to that from the bottom, that there is still a large economy effected by the new type of hammer. The diagrams—Figures 6 and 7—taken during the above tests are full of interest and speak for themselves.

The hammers are substantially constructed, have few wearing surfaces, and are well lubricated, while their method of operation is simple. Any weight of blow, from light to full normal, dead or holding-down blows, can be given by the movement of the lever. When the latter is released, the tup rises and remains in its highest position.

Figure 8 shows in section a hammer with an alternative form of valve chest. This design is used for heavier types of hammer.—*The Engineer,* London.

THE REACH OF SCIENTIFIC SPECULATION

In a recent address at Lehigh University John A. Brashear gave the following illustration of the minuteness of the atom:

"If you fill a tiny vessel, one centimeter cube, with hydrogen corpuscles, you can place therein, in round numbers, five hundred and twenty-five octillions (525,000,000,000,000,000,000,000,000,000) of them. If these corpuscles are allowed to run out of the vessel at the rate of 1,000 per second it will require seventeen quintillions (17,000,000,000,000,000,000) of years to empty it. Such a computation seems almost like trifling with science, indeed apparently trifling with the human intellect; but it is with these subtle theories that our physicists are wrestling, delving into the innermost chamber of the infinitely minute to build for us, upon the most stable foundation, the macrocosm of a universe."

OPERATING RECIPROCATING STEAM PUMPS BY THE DENSE-AIR SYSTEM

By Snowden B. Redfield.

From time to time I have had occasion to figure upon various methods of pumping water by means of compressed air, and a detailed study of the Dense-Air System of operating reciprocating steam pumps has developed much that should be of interest to those using compressed air.

By the Dense-Air system is meant that method of operating which comprises an air compressor delivering air at high pressure to some machine, such as the reciprocating steam pump, which after the air has done its work, exhausts it into a closed piping system leading back to the compressor intake, the pressure in this closed exhaust pipe being kept at some figure above, and usually considerably above, that of the atmosphere. It is well known that by this method of operation there is a considerable gain in economy, and the purpose of this article is to show, in a simple way, under what conditions this economy is obtained and what its value is.

A number of curves have been plotted which show the corresponding results of operation by various methods of Dense-Air application, compared with compressed air operation with ordinary atmospheric pump exhaust and compressor intake. Before examining these curves in detail a few words as to the cause of the increased efficiency by this system of operation will serve to make the matter clearer. Gauge pressures only are used.

Figure 1 shows a theoretical combined indicator card for ordinary straight compound air operation with 100 pounds compressor discharge pressure and atmospheric intake. Figure 2 represents Dense-Air operation with 150 pounds compressor discharge pressure and 50 pounds intake. The latter system of operation involves only single-stage compression, because the ratio of compression is only 2.54, as compared with 7.58 for the atmospheric system. The range of pressures, or the difference between the discharge pressure and the intake pressure, is the same in both cases, namely, 100 pounds, and it will be shown that the mean effective pressure in the pump cylinder to be operated is also the same in both cases. This small ratio of compression in the Dense-Air system, with a given difference of pressures, is the cause of the increased economy of the latter.

In Figure 1 the length, A G, is supposed to represent a piston displacement volume of 10 cubic feet. With a cylinder ratio of 2.8 : 1, the length of the line, B K, will represent the volume of air discharged into the intercooler with adiabatic compression. This volume will be 4.82 cubic feet. After intercooling, this length will be reduced to C K, or the volume will be reduced to 3.57 cubic feet. At this point the air is supposed to have been cooled to the initial temperature of the intake to the low-pressure cylinder, and this is the volume which enters the high-pressure cylinder. Again compressing adiabatically, at 100 pounds, the compressed air will have a volume of 1.72 cubic feet, represented by the length, D F. Aftercooling, or radiation, in the pipe line reduces this volume to E F, or 1.28 cubic feet, by the time the air enters the actuating cylinder of the pump. This is, of course, the same as the volume obtained by compressing up the isothermal line, A C E, and the air is again at intake temperature.

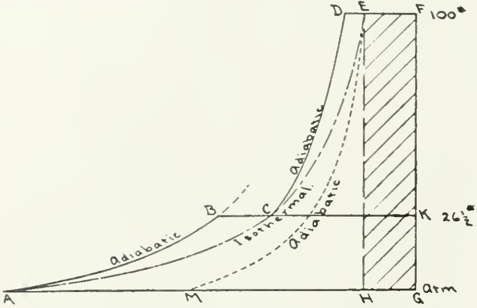

Fig 1.

Assuming that the pump cylinder is to operate without cut-off, and assuming also that there is no loss of pressure in the pipe line, the length, E F, will represent the volume of air admitted to the pump cylinder at 100 pounds. At the end of the pump stroke release will take place and the pressure will drop down the line, E H, to atmosphere. On the back stroke the air remaining in the pump cylinder is exhausted along the line, H G, into the atmosphere, and at the end of the stroke a new admission of air takes place and the pressure rises up the line, G F. By this it is seen that the rectangular shaded diagram, F E H G, can represent the indicator diagram of the air cylinder of the pump, and the area of this diagram will represent the useful work done by the air in this cylinder.

It will be noted that with this rectangular diagram the mean effective pressure of the air exerted on the pump piston is 100 pounds per square inch, or the same as the difference between the discharge and intake pressures of the compressor. The area of this card, or the work done on this pump piston, will be equal to the total mean effective pressure times the volume swept through by the piston. This with 1.28 cubic feet of compressed air, as shown above, will be $100 \times 144 \times 1.28 = 18{,}430$ foot-pounds. If this work is done in one minute it will be equivalent to 18,430 divided by 33,000, or .558 indicated horse-power. This power has been developed in the actuating cylinder of the pump by what was originally 10 cubic feet of free air admitted to the compressor cylinders in one minute. To compress 10 cubic feet of free air per minute by compound adiabatic compression to 100 pounds there will be required 1.535 indicated horse-power in the compressor cylinders.

The efficiency of the system is then: Power developed in pump cylinder divided by power required in compressor cylinders, or .558 divided by 1.535, which equals 36.4 per cent.

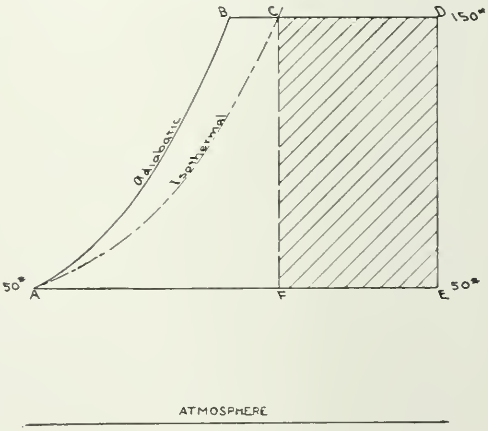

Fig. 2

Turning to Figure 2, which represents operation by the Dense-Air system, the line, A E, represents as before 10 cubic feet of piston displacement, but in this case at 50 pounds gauge pressure. Compressing adiabatically in a single-stage to 150 pounds gauge pressure, gives the volume 5.15 cubic feet of compressed air, represented by the line, B D. This volume cooled to intake temperature would be

3.94 cubic feet, shown by line, C D. This volume of cold compressed air passes to the actuating cylinder of the pump and, as before, there will be admission, release and exhaust in the pump cylinder, forming a rectangular indicator card, but with 150 pounds initial pressure and 50 pounds exhaust pressure. This indicator card is represented by the figure, D C F E. The work done by this rectangular card with 3.94 cubic feet of compressed air admitted to the pump cylinder, as shown, and with a mean effective pressure of 100 pounds per square inch, as given by this rectangular indicator card, will be 100 × 144 × 3.94, which equals 56,700 foot-pounds. Assuming this work to be done in one minute, this would represent

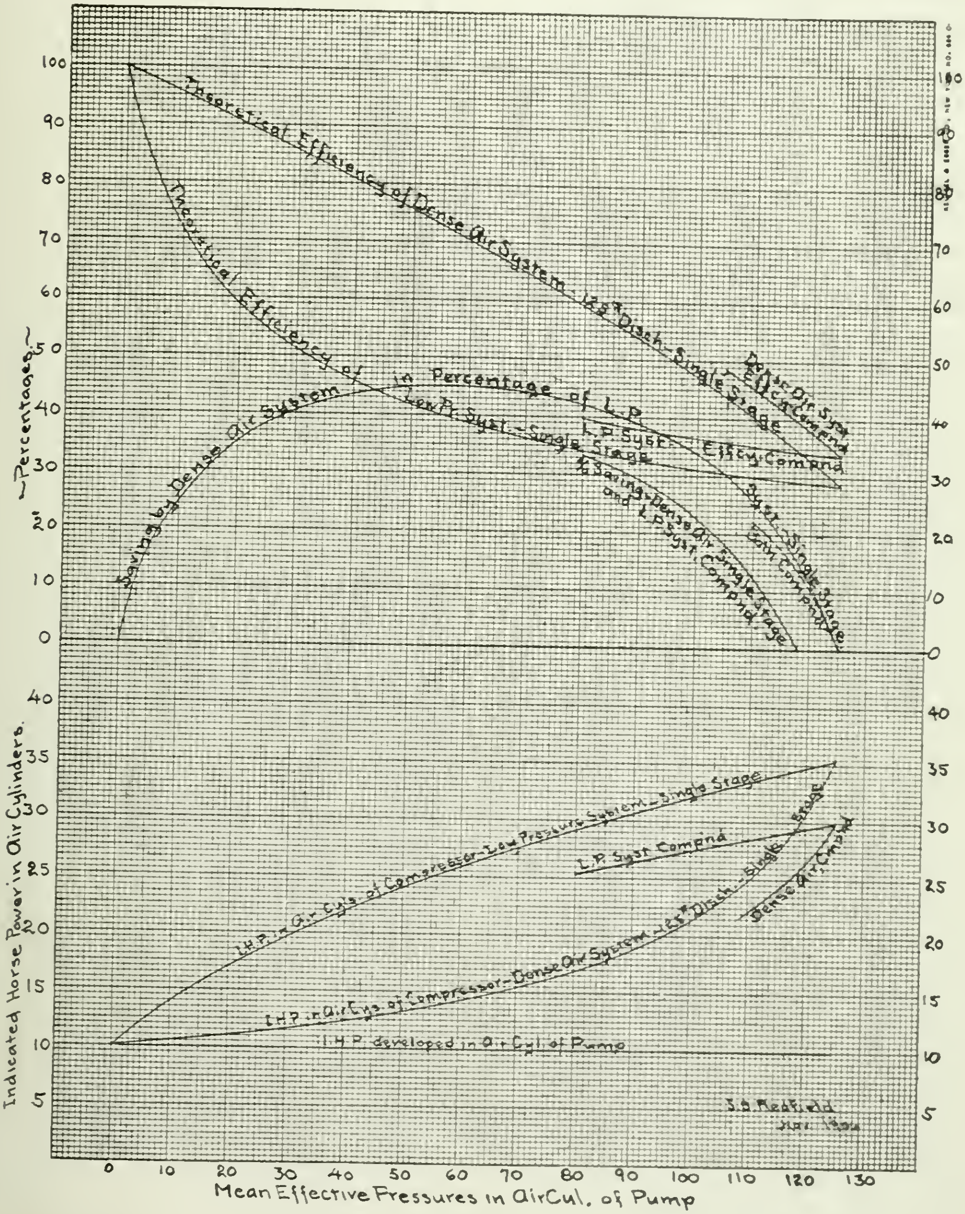

FIG. 3.

1.72 indicated horse-power in the air cylinder of the pump. To compress adiabatically in one stage 10 cubic feet piston displacement of free air per minute from 50 to 150 pounds requires 3.04 indicated horse-power in the air cylinder of the compressor. These figures, then, give the efficiency of this Dense-Air system equal to: Horse-power developed in pump cylinder divided by horse-power of air compressor cylinders, or 1.72 divided by 3.04, which equals 56.5 per cent.

With the straight-air operation, having compressor intake and pump exhaust at atmosphere, there was obtained an efficiency of 36.4 per cent, and with the Dense-Air system it has been shown that the efficiency is 56.5 per cent; thus the gain in efficiency is apparent.

It will at once appear that the gain in efficiency will depend upon the pressures and the range of pressures chosen, and it is obvious that the smaller the ratio of compression the greater the economy. It naturally follows that the advantage lies with high initial pressure and correspondingly high back pressure, giving a small ratio of compression.

As before said, all the foregoing calculations are based on a mean effective pressure of 100 pounds per square inch in actuating cylinder of pump, the mean effective pressure being the same as the difference between the maximum and minimum pressures, or the pressure range of the cycle. In actual practice a maximum pressure of 125 pounds in the pump cylinder is about the upper limit to which the manufacturers desire to go without special construction and extra expense. For this reason it will be well to confine further arguments to this practical limit.

It is obvious that with a given size of pump cylinder the work performed depends upon the mean effective pressure in that cylinder. This being the case, the comparison of results for any two systems of operation should be made on a basis of the same mean effective pressure in the two cases. For the purpose of showing the results of operation with various mean effective pressures, a number of curves are given (Figure 3), which are calculated on a basis of developing 10 indicated horse-power in the actuating cylinder of the pump.

These curves are entirely theoretical, being based upon adiabatic compression in the compressor cylinders, with no losses due to friction, clearance, throttling or pressure drop. These losses would, however, occur in both systems, and for a basis of general comparison, the theoretical curves will serve a very good purpose.

In the case of the Dense-Air system the maximum pressure is always kept at 125 pounds gauge and the lower pressure is set to give the desired pressure range. For the low-pressure system, the maximum pressure is set to give the desired pressure range, while the minimum pressure is always atmospheric. As an example, suppose it is desired to obtain a mean effective pressure of 50 pounds per square inch, as shown by the rectangular indicator card of the pump cylinder. In the Dense-Air system, the maximum pressure is to be kept at 125 pounds gauge, so the minimum pressure must be 75 pounds gauge, in order to give the desired range of 50 pounds. For the low-pressure system, the minimum pressure must be kept at atmosphere, so the maximum pressure must then be 50 pounds gauge. Thus, these two cases have the same pressure range, or 50 pounds mean effective pressure in the pump cylinder, and the various theoretical results obtained by the two systems are clearly shown and compared by the curves for this, and for other mean effective pressures from zero to 125 pounds. In all cases the pump cylinder is here supposed to be made the correct size to develop the 10 indicated horse-power with the mean effective pressure assumed.

In these curves horizontal distances represent mean effective pressure in pounds per square inch in the actuating cylinder of the pump, while vertical distances represent respectively, beginning at the bottom: indicated horse-power in air cylinders of compressor required to develop 10 indicated horse-power in actuating cylinder of pump; saving of power by Dense-Air system in percentage of power required by low-pressure system, and, finally, the efficiencies of the two systems, or ratio of indicated horse-power developed in actuating cylinder of pump to indicated horse-power required in air cylinders of compressor. The various curves are so marked as to be readily understood.

Examining the lower, or indicated horse-power curves, it will be noted that the curves for the Dense-Air system and the low-pressure system come together at two points. First, at the point of 125 pounds mean effective pressure we have for both the Dense-Air system and the low-pressure systems simply straight compression from atmosphere to 125 pounds. The curves show that to develop 10 indicated horse-power in the pump cylinder requires 35.3 indicated horse-power to be developed in the air cylinders of the compressor by either system by single-stage compression, and 29.8 indicated horse-power by compound compression. At this point the percentage saving of the Dense-Air system over the low-pressure system is, of course, nothing, as is shown by the curves of saving. Also at this point the efficiency of the two systems is the same, and is 28.2 per cent for single-stage and 33.6 per cent for compound compression, and is shown by the fact that the efficiency curves meet at this point.

The other point at which the indicated horse-power curves come together is at the point of zero mean effective pressure. This is a point where there is a very curious state of affairs, which can be viewed only from the theoretical standpoint. To properly examine the conditions here obtaining it is necessary to take the view of mathematicians on the subject of the value of Zero. To quote the expression of professors of mathematics—"Zero is not *nothing;* it is an infinitely small quantity, just disappearing!" This being the mathematician's viewpoint, it follows that zero multiplied by infinity, has a finite value.

Now to return to the curves:

At the point of zero mean effective pressure there is then an infinitely small mean effective pressure acting on the pump piston. It follows that in order to perform 10 horse-power of work it is necessary to have an infinitely large piston area, or cylinder volume. It is now perhaps possible to imagine a compressor indicator card with an infinitesimal height and infinite length. Being only infinitesimally high, the curve of adiabatic compression is infinitely short, and consequently the area under this curve is infinitely small. As the area under this curve represents the work lost in heat, this loss must be infinitely small. If the losses are then infinitely small, the amount of work done in the pump must be equal to the work done in the compressor, with the exception of this infinitely small loss. This means that the efficiency of the system must be infinitely near 100 per cent. The foregoing results hold both for the low-pressure system and for the Dense-Air system. In the former system the compressor intake is only an infinitely small amount greater than this, so that the range of pressures, or the mean effective pressure in the pump cylinder, is infinitely small, or zero. In the Dense-Air system the discharge pressure is, as before, 125 pounds and the compressor intake is only an infinitely small amount less than this, so that the mean effective pressure is again infinitely small, or zero, and in both cases there is an efficiency of 100 per cent, as shown by the above reasoning.

Referring to the curves it will then be noted that at the point of zero mean effective pressure in the pump cylinder, the curves of indicated horse-power of compressor come together for both systems at the point of 10 indicated horse-power, also the curve of saving passes through zero, and the curves of efficiency for the two systems meet at the point of 100 per cent.

Curves are given showing comparison between operation by both systems, single-stage; both systems, compound, and low-pressure system, compound, with Dense-Air system, single-stage. The compounding has been limited to those pressure ranges where it would be advantageous from a commercial standpoint, and to the compressor cylinders only. The pump is always single-stage.

After this careful study of the Dense-Air system, from a theoretical standpoint, it will be interesting to make some calculations based on what might be expected in actual practice, taking into account all losses due to friction, throttling, pressure drop in air line and clearance. For this purpose let the problem be as follows:

Quantity of water to be lifted, 400 gallons per minute.
Lift, 830 feet.

This lift, counting in 10 per cent pipe friction, would amount to a water pressure of about 400 pounds at the pump. Glancing at the curves for saving of power by the Dense-Air system, it will be noted that the maximum saving with 125 pounds maximum air pressure at pump, is obtained with a mean effective pressure of between 50 and 60 pounds in the air cylinder of the pump. Bearing this in mind, it is advisable to use such a cylinder ratio as to obtain this mean effective pressure. Of course, a lower mean effective pressure would give a higher efficiency, as shown by the curve, but the size of the air cylinder of the pump must be kept within practical limits.

This mean effective pressure gives a very satisfactory cylinder size, and at the same time gives the greatest saving over the straight-air system.

For the purpose of doing this pumping with a commercial size of pump, assume one of duplex construction, having two air cylinders 32-inch diameter by 36-inch stroke, and two water cylinders, 10-inch diameter by 36-inch stroke. Allowing 10 per cent slip of water, a piston speed of 55 feet per minute for each side of the pump would handle the required 400 gallons per minute. This amounts to a piston speed of 110 feet per minute for a simple pump. With the water pressure given above and with the given cylinder ratio, the mean effective pressure required in the air cylinder to drive this pump, including 80 per cent mechanical efficiency between the two cylinders, would be 48.7 pounds per square inch. Assuming a diagram factor of 90 per cent, due to throttling and the rounding of the indicator card as obtained in actual practice, the theoretical mean effective pressure required to drive this pump will then be 54 pounds. Let the air pressure at the pump throttle be 125 pounds. In order to obtain 54 pounds theoretical mean effective pressure, the back pressure of the pump will have to be 71 pounds. Allowing 5 pounds drop in the pipe line from the compressor to the pump and 6 pounds drop from the pump back to the compressor intake, the pressures at the compressor will be 65 pounds intake and 130 pounds discharge. There is then a range of pressure of 65 pounds at the compressor and 54 pounds at the pump. With 110 feet piston speed, the volume of the air cylinders of the pump will be 612 cubic feet per minute. This volume filled with air at 125 pounds amounts to 5,820 cubic feet of free air per minute. This quantity of air returned to the compressor at 65 pounds amounts to 1,073 cubic feet per minute. Assuming the clearance of the pump cylinders to be 10 per cent, and bearing in mind that this clearance space is filled at each revolution of the pump with air at 125 pounds and expanded down to 71 pounds at release, there is a quantity of air used by this clearance equal to 225 cubic feet of free air per minute. This returned to the compressor at 65 pounds is equivalent to 42 cubic feet. This added to the amount usefully used in the pump cylinder and the total increased by about 3½ per cent for piston leakage, would amount to 1,155 cubic feet of compressed air at 65 pounds returned to the compressor cylinders.

Assuming about 93 per cent volumetric efficiency for the compressor, there will then be required a piston displacement equivalent to 1,240 cubic feet per minute. To compress 1,155 cubic feet of air from 65 pounds to 130 pounds by single-stage compression would require about 295 indicated horse-power in the air cylinders of the compressor. The work done in the air cylinders of the pump is equal to the mean effective pressure multiplied by the volume swept through by the piston. With 49 pounds actual mean effective pressure in the air cylinders of the pump and with 110 feet piston speed per minute, there will be developed 131 indicated horse-power in these cylinders. What might be termed the thermal efficiency, then, is the indicated horse-power of the air cylinders of the pump, divided by the indicated horse-power of the compressot. This, then, is 131 divided by 295, which equals 44.4 per cent. This figure is what corresponds to the figures given by the curves of efficiency, with the exception that in this case all probable losses have been taken into consideration, whereas the curves are purely theoretical.

The theoretical efficiency, according to the curves, for the conditions outlined for this problem, is 76 per cent; 44.4 is about 59 per cent of this theoretical value. Under ordinary conditions it may be assumed that the actual efficiency to be expected from such a system as this is from 55 to 65 per cent of the efficiency which would be calculated from a strictly theoretical analysis.

Comparing the above problem with operation by straight low-pressure air, taking into account all losses as before, it would be possible to operate this pump with 54 pounds at the throttle and atmospheric exhaust. It is clear from the previous reasoning that this range of pressures would give the same mean effective pressure in the pump cylinder, namely, 54 pounds theoretical or 48.7 practical. Allowing 6 pounds drop in the pipe line, the compressor could discharge at 60 pounds, having atmospheric intake. As before, the piston displacement of the pump cylinders would be 612 cubic feet per minute. This volume filled with air at 54 pounds would amount to 2,860 cubic feet of free air usefully used per minute. With 10 per cent clearance and 54 pounds initial pressure and 2 pounds back pressure, the clearance would consume about 216 cubic feet of free air per minute. This added to the previous amount, plus about 3½ per cent for piston leakage gives a total quantity of free air required to operate this pump of 3,196 cubic feet per minute. With 92 per cent volumetric efficiency of compressor this would require a compressor piston displacement of 3,480 cubic feet per minute. To compress 3,196 cubic feet of free air per minute to 60 pounds, single-stage, would require about 473 indicated horse-power in the air cylinders of the compressor. As before, the indicated horse-power of the pump cylinders would be 131, and the efficiency of the system is, therefore, 131 divided by 473, which equals 27.7 per cent; thus it is evident that the efficiency by the Dense-Air system even from a practical standpoint is much greater than that by straight low-pressure air operation. To carry this problem still further and to make a commercial comparison, it is advisable to calculate the steam which would be used to drive this pump if used directly in the pump cylinder and the steam which would be used by an air compressor to do this work—295 indicated horse-power in the air cylinders of the compressor would amount to about 330 indicated horse-power in the steam cylinders. Assuming 100 pounds steam pressure, compound, noncondensing, a rate of about 22 pounds of steam per indicated horse-power per hour could be expected. This compressor would then use 7,260 pounds of steam per hour. In a reciprocating pump of the kind under consideration the steam rate would be at least 75 pounds per indicated horse-power per hour. The indicated horse-power of the actuating cylinders of this pump was found to be 131. At 75 pounds steam rate this would be equivalent to 9,820 pounds of steam per hour. The result, then, is that the air compressor will use 7,260 pounds of steam per hour, as opposed to 9,820 pounds of steam used directly on the pump. This means that the compressor will use 74 per cent of the steam which would be used for direct steam operation, and still perform the same amount of work and lift the same quantity of water.

Returning to operation by low-pressure air: It was found that the air cylinders of the compressor would develop 473 indicated horse-power in order to perform 131 indicated horse-power in the pump cylinders; 473 indicated horse-power in the air cylinders is equivalent to about 525 indicated horse-power in the steam cylinders of a steam-driven compressor. With the same steam rate as before—that is, 22 pounds per indicated horse-power per hour—this compressor would require 11,560 pounds of steam per hour. This quantity of steam is, of course, greater than that required to operate the pump by steam used directly in the cylinders, so there would have to be some reason other than economy only for operating this pump by low-pressure air.

This saving of fuel is a very attractive argument, but it is not advisable to jump to too hasty conclusions as to the use of the Dense-Air system for other purposes than the operating of reciprocating steam pumps. With such a machine as the pump considered, which would operate with fair regularity, and which would not have to be continually moved about as a rock drill would have to be, the conditions are practically ideal. When it comes to operating an engine having cut-off and expansion, by Dense Air, the results to be obtained depend upon the cut-off, the release pressure, the minimum allowable temperature and the mean effective pressure, which all again depend upon each other. The combined effect of all these items complicates the problem beyond the possibilities of this article. It is sufficient to say, however, that with early cut-off, little or nothing can be gained by Dense-Air. The gain is greater the later the cut-off, and the later the cut-off the nearer the case approaches that of the pump already discussed. It would hardly seem that the gain to be obtained by Dense-Air operation of expansive engines in actual practice would warrant the additional complication, except under extraordinary circumstances.

For rock drills operated by the Dense-Air system there is a great disadvantage, in that it necessitates two lines of piping. As the piping of a rock drill plant is usually very temporary, and, even with the best of care, liable to excessive leakage, this double line of piping, with the increased pressures, makes this condition worse than ever. Also the necessity of having two sets of piping to connect up, handle and move from place to place, makes the use of Dense Air with rock drills more of a disadvantage than otherwise, and with pneumatic tools it is, of course, out of the question.

Even when operating a reciprocating pump, which it has been shown is the most desirable machine to operate with the Dense-Air system, there is the very great disadvantage that a separate compressor termed the "booster" is necessary in order to make up the leakages in the air line, as, even with the most careful attention, some leakage is bound to occur and this must be made up in order to keep the pressures at the proper points. The horse-power of this compressor should, of course, be added to the horse-power of the main compressor and this will reduce the efficiency of the system to a greater or less extent, depending upon the amount of leakage.

From the foregoing argument it now appears that before using the Dense-Air system it would be most advisable to give careful consideration to all the advantages and disadvantages as herein outlined, and any particular case must be settled on the conditions to be met in that case and conclusions drawn must be based upon these conditions. As with most things of merit, if the conditions are right, and proper use is made of it, a very considerable gain can actually be obtained by the use of the Dense-Air system.

THE ROCK DRILL AND THE AIR COMPRESSOR IN COPPER MINING

As the average yield of copper ores is only 2 to 3 per cent of metal, some ores being handled with profit which yield but 1 per cent of metal, the importance of economy in all the operations and agencies is evident. With such low-grade ore a cent more or less in the cost of getting out and treating a hundredweight of ore would mean an equal difference of cost per pound of metal produced. Copper mines therefore have always been in the lead in the development and adoption of the most advanced mechanical facilities, and it is no wonder that they have been notorious scrappers all along of costly machinery as improvements have successively become possible.

Copper mining is credited with the first successful use of steam engines, of iron skips and cages, iron and steel cables, high explosives and air-driven rock drills. The first steam engine, Savery's, was erected in a copper mine in Cornwall, England, two centuries ago. Newcomen's engine, which was an improvement upon this, was also in a Cornish copper mine, and Watt's first engine was for mine pumping at Chacewater, Cornwall.

The copper mines of Lake Superior and of Montana have practically killed the mines of Cornwall, and now these latter lead the mines of the world in the depths of their openings and in both the capacity and the economy of their hoisting, pumping and air-compressing machinery. The first copper mining in the Lake Superior region was in 1844. Calumet & Hecla was opened in 1866. In 1880 the Butte deposits were discovered. Anaconda mine was first opened as a silver mine.

The first Rand drill was placed in the Calumet & Hecla in 1878, and at the beginning it had to make a desperate fight for existence. The mining costs in the decade between 1881 and 1891, during which these drills got under full headway showed changes as follows: Stoping per fathom, 1881, $14.35; 1891, $4.33; drifting, 1881, $10.08; 1891, $4.92. High explosives must be given part of the credit. In Calumet & Hecla for the seven years after the introduction of the Rand drills the following was their record: Sinking shafts and winzes, 20,715 feet; drifting veins and cross-cuts, 78,660 feet; stoping, 83,997 fathoms; or nearly 4 miles of shafts and 15 miles of drifts. The rock thus removed amounted to 291,333 cubic yards in drifts and 671,976 cubic yards in stopes. The shops of the company now dress 50 tons of drill steels per day.

The Calumet & Hecla built for itself the biggest air compressors in the world; one Leavitt compressor having a nominal capacity of operating 500 drills though never actually running over 300. Some of these early compressors had their mission in showing what is *not* best in air-compressing practice. The wet compression principle is now practically abandoned, and, also, the building of air compressors, as with the building of pumps, of machine tools and other lines of machinery, has gone into the hands of concerns which make it their specialty, and the air compressors of the Rand or of the Ingersoll-Sergeant Companies are found in practically all of the copper mines of America and a list of them is impossible in the present publication.

The following Ingersoll compressors are in the service of a single mining company in Montana, only the diameters of the first air cylinders being given: two 60-inch, one 50¼-inch, one 38¼-inch, one 36¼-inch, one 30¼-inch duplex, three 24¼-inch duplex, three 22¼-inch duplex, two 24¼-inch, one 37¼-inch four-stage for charging mine locomotives.

These fifteen compressors have a combined capacity of 60,000 cubic feet of free air per minute, and all except one or two of the oldest of them are high-class machines, embodying the devices which promise the best economy both in the development of the power from the steam and in the application of the power to the compression of the air and the delivery of it in condition most fit for use, these characteristics being common to nearly all of the numerous air compressors employed in this vast industry.

COST OF ROCK DRILLING IN SWEDISH MINES

"The use of boring machines, which was at first confined to rising in the back of levels, has during the past ten years been extended to cutting plat, shaft sinking and driving the ends. They have shown their advantages, even at a higher price per unit of depth of hole bored. In the Lomberg mining district machines weighing 88 to 110 pounds, with piston of 2-inch diameter, have bored 24.67 feet per shift of eight hours, yielding 4.34 tons of rock per metre bored, against 3.45 tons with hand boring (1.32 against 1.05 ton per foot), notwithstanding that the effect of the explosive was diminished from 1.59 tons per kilogram to 10.83 tons (7.21 to 9.49 tons per pound.). The cost per ton of spoil was 10.4 cents, including miners' and fitters' wages, sharpening drills, repairs and powder, but nothing for redemption. Hand boring costs only 10 cents per ton, but the machine did the work of more men. In the same district the cost of driving levels of 43 square feet area has been $3.75 per lineal foot by machine boring, including the same items as above, as against $4.08 by hand; or, say, for levels 6 feet wide by 6 feet high, $3.20 per foot forward by machine, against $3.44 by hand. Here the chief gain is that the ends are driven more than twice as fast by machine.

"Pneumatic drills are at present maintaining their superiority over electric, which only under exceptional circumstances can compete with them. At Gräugesberg the author's experience has been that although electric drills take less power, they are not cheaper in working, because what is gained in power is lost in diminished efficiency, and in greater wear and tear. With electric drills the depth bored per core (shift?) has run up to 22.31 feet in ore and 19.30 feet in country, with an average depth of 8.53 feet per hole. With pneumatic drills the corresponding figures have been 32.15 feet and 25.65 feet or roundly 8.2 feet more per core (shift?) with the advantage of better ventilation underground.

"In the Rand and Ingersoll machines the piston and drill are in one piece, so that they move together. For some years trials have deen made, at Gräugesberg and several other mines in Sweden of an American water jet machine (probably the Leyner drill), in which the piston is separate from the drill and strikes it with great rapidity. Water is ejected by compressed air through the hole, and as the drill always strikes on a clean surface, the effect is considerably increased, while the difficulty with the dust is obviated. At Gräugesberg this machine has bored 9,648 feet in 290 cores (shifts?) or 33.3 feet per core, where the Rand machine did no more than 25.82 feet. But the difficulty is to get the steel to stand; the American drills were useless in the hard stone of the Swedish mines. The Storfers works have now succeeded in making a thoroughly good drill steel.

"The bore holes can be drilled by machine both deeper and larger than by hand with augmented effect. In open quarrying at Gräugesberg the quantity of stone loosened per metre (3.28 feet) bored has been increased from 4.57 to 1.2 tons (1.39 to 3.41 tons per foot), and in hard compact rock to 18.7 tons (5.7 tons per foot), with holes averaging 9.25 feet deep and 1 inch diameter at bottom. At Kiruna, where the holes are bored twice as deep and 1.6 inches in diameter, the quantity per metre bored has averaged in three months 102.3 tons (31.2 tons per foot) and in some places has gone up to 180 tons (55 tons per foot).

"With the larger and more effective bore holes the rock is blasted in large blocks, which have then to be drilled and blasted smaller for removal. For this purpose portable mechanical jumpers—pneumatic percussion drills held in the hand and requiring no stand—have been devised during 1905 by the Ingersoll firm and by the Atlas Company, Stockholm, both of which have been tried at Gräugesberg on four different kinds of rock. The author considers that hand boring ought speedily to disappear from mines equipped with compressed air."—*Teknish Tidskirft*, Stockholm.

SUBMERGED ROCK CRUSHING

The Lobnitz chiseling machine for submarine rock excavation, like many other devices, has its special field of employment in which it is highly successful. It is being used with satisfaction in harbor improvement work at Blyth, near the northeast corner of England. Drilling and blasting with subsequent dredging were first employed, 150,000 cubic yards of rock having been taken out in this way. A chiseler plant consists of a steel barge carrying at one end shear-legs from which is suspended a steel ram weighing 15 tons. It is about 45 feet long and 18 inches in diameter, with a renewable hard conical point. The ram has a drop of 8 feet and an average of eight or nine blows is sufficient to penetrate or crush the sandstone rock about 3 feet, so that 2½ feet at a time can be dredged. One machine working night and day with average stoppages breaks up about 900 cubic yards per week at a cost of $0.18 per cubic yard. Contingent and incidental expenses for operation and maintenance make the final cost $0.29. Drilling and blasting cost about $0.72 per cubic yard and the rock was left in a somewhat less favorable shape for removal. The drilled and blasted rock cost $0.76 per cubic yard to dredge, while the chiseled rock cost $0.66.

POWER ECONOMY IN RETURN AIR

In learning to use compressed air economically the same course has been traversed as in the use of steam, although the lesson having been first and completely learned with steam as the motor fluid, it might have been expected that once thus learned it might have been much more quickly appropriated by the users of the air. Steam was first used to fill a cylinder or other chamber, at full pressure, and to do what work it was capable of at that pressure, and then it was discharged at that full pressure into the atmosphere, or into the condenser. Steam so used was the passive transmitter of the pressure in the boiler, and itself really did no work. The use of steam expansively, allowing its elasticity materially to augment the total of work accomplished, was a later achievement.

So when compressed air is applied, in what has been the usual way, to the operating of the familiar apparatus, to the rock drill, the direct air hoist, or even in driving a steam pump, the air, which is used at full pressure and is then discharged, actually does no work with which it may itself be credited. A passive column of it is simply pushed along by a force behind it, either actually by the compressor itself, or by the slight expansion of the large body of air in the receiver and mains, and this notwithstanding the fact that the air, each individual cylinderful of it, is capable of doing work by its expansion all the way down to the pressure of the atmosphere into which it is finally discharged.

We may believe that the great gains accomplished by the use of steam expansively were not ignored by the earlier users of compressed air, the simple fact being that while they would gladly have saved the wasted power, they did not at first, nor for a long time, see the way to do it. Compressed air, for instance, has been many times employed for forcing water to higher levels. With a chamber full of water, and a discharge pipe leading up to the height at which it was desired to deliver the water, air of sufficient pressure would be admitted to the chamber above the water, and the air would drive the water up the pipe. When the operation was completed the chamber would be full of compressed air, and then the question would come up as to what could possibly be done with this air except to discharge it into the atmosphere so that the chamber might fill with water again, and as no answer was forthcoming the air would be discharged and all its expansive force would be wasted, this practice ruling from the very earliest use of compressed air until quite recently, when a device, which in principle is extremely simple, solved the perplexing problem. The return-air pumping system, instead of discharging the air at its full pressure, pipes it back to the intake of the air compressor; in its reëxpansion this air helps the compressor piston to do its work, and this help reduces to that extent the power-cost of compressing the air to the pressure required for forcing the water.

The electric air rock drill, another quite recent invention, is a return-air apparatus which accomplishes results still more astonishing in the way of power economy in the use of compressed air. It transforms the extravagant wastefulness of the familiar air-driven rock drill into the completest economy in the transmission and application of power, under the most difficult and exacting conditions. In this case not only is the elastic force of the air entirely utilized, but there are no losses in the filling of clearances, and the cushioning of the piston is only a carrying over of force from one stroke to the next.

It is evident, therefore, that the development of efficiency in the use of compressed air has attained a point impossible with steam, since practically all the energy contained in the exhaust is returned to the compressor.—*Cassier's Magazine.*

PIT SINKING THROUGH FROZEN QUICKSAND

Mr. E. Seymour Wood recently read a paper before the North of England Institution of Mining Engineers describing a remarkable feat of shaft sinking through quicksand by the aid of the freezing process. The coal mine is located close to the east coast of the county of Durham, which lies south of Newcastle and the Tyne.

The difficulties of sinking shafts in the East Durham district arises from the occurance of magnesian limestone and underlying yellow sands, the latter being usually found as a quicksand, and both of these strata contain large quantities of water. At Dawdon, the magnesian limestone is 356 feet thick, and the yellow sand 92 feet thick. The limestone as is usual, is full of gullets, giving off large quantities of water. Some of these gullets are connected with the sea, the water issuing from them being salt. The question was therefore considered whether to erect additional pumping plant or to carry out the sinking of the shafts through the sands in a frozen state. It was decided to adopt the freezing process. Accordingly, the shafts, each enclosed in a wooden shed, were handed over to the contractors, Messrs. Gebhardt and Koenig, Nordhausen, in April, 1903. This firm undertook the freezing of the ground through which the two shafts were to be sunk, and also the adjoining ground, to such an extent as to enable the owners of the colliery to carry out their sinking arrangements without the air of pumps, until each shaft was sunk to a depth of 484 feet from the surface, and to establish and maintain a solid wall of ice around each shaft, so long as should be necessary for the purpose of sinking. Twenty-eight bore holes were marked off in a circle 30 feet in diameter surrounding the shafts and were bored to a depth of 484 feet. After the whole of the freezing tubes were inserted, they were connected to the inner and outer collectors, for the circulation of brine. The length of time required to form the ice wall at the Castlereagh shaft was 185 days. The ice wall was maintained 353 days, and the total time of freezing was 538 days. The sand was struck at a depth of 371 feet and found to be frozen hard. In the shaft bottom the frozen sand was so hard that blasting had to be continued throughout the deposit. The temperature of the frozen sand at the bottom of the pit was —14C, (+6F.) The thawing of the frozen ground was accomplished by circulating warm brine through the freezing tubes. Once through the frozen sand the progress of the operations was very brisk.

A CORNWALL ROCK DRILL INVENTOR

Of inventions and inventors there is no end. The number of rock drills is legion, and the claims put forward on their behalf are still more so. The other day I was asked to visit the house of an old miner, who had manufactured a rock drill of his own, worked by hand or other power. The machine was, of course, in an incipient stage, and being built on wooden supports was perhaps hardly up to the stability required for continuous practical working; but it contained a number of ingenious ideas, including even a water spray arrangement of original design, the water being fed from a bucket placed anywhere handy. Strange to say, the old man had never seen a real rock drill at work, although he had been a miner all his life. On one occasion, indeed, in passing through Camborne, he had seen one in the window of a firm there, but his wife, who was with him, he mildly complained, was in too great haste to allow him to study its details. Certainly, however, his own design was in no way similar to any other known drill. The earnestness and enthusiasm with which the old man would set the machine working, punching holes in large stones, spraying them profusely with water the while, was—well, interesting. He was very anxious that someone should take up his invention and patent it. Undoubtedly he had exercised great ingenuity, but unfortunately the result would not, of course, for a moment compare with the magnificent machines now turned out by Cornish and other firms. Finally, he let out that he would like someone to purchase the machine from him, as he had an idea for a still better one in his head! Still, I think it would have broken his heart if he had parted with it.

COMPRESSED AIR DRAFT FOR HEATING RIVETS

It has often been said that the effect of compressed air draft when used in connection with oil fuel without a fire wall in the furnace, produces not only a hard rivet but a hard, thick scale on the same. As regards compressed air draft, causing rivets to become hard, it is only an assumption, and right here is the place to ask, "Who can positively say that it does?" To the writer's knowledge no man has ever made scientific tests to determine the actual amount of hardness produced in steel rivets through heating them by means of liquid fuel and compressed air, and I would ask, would it not be reasonable to believe that the furnace is always hot enough to absorb all of the moisture contained in compressed air long before it reaches the rivets. If it did not what harm could it possibly do to the body of the rivet? I will venture to say none, from the very fact that any kind of heating of mild steel, such as rivets are made from, tends to anneal it. As rivets are made from mild steel by a similar process to that of our steel boiler plate, and we all know that we can heat this red hot, then quench it in cold water and bend it double: pray, tell us, what harm a little moisture in a furnace could possibly do to a steel rivet? In the writer's opinion, very little, if any.

Then, again, let us take a broad view of it: Suppose that if it did have a tendency to make the rivet harder this would be in its favor, as rivets are subject to a shearing strain, and if they become harder after they are driven it would only increase the shearing strength. To make them soft enough to drive it would only be necessary to bring them to a heat that would be best suited for the kind of riveting to be done, whether it be hand, snap, pneumatic, hydro-pneumatic, compression or hydraulic. Therefore, the effect of heat upon steel rivets, aided by forced draft, which includes compressed air, is of so little consequence that it ought not be given consideration by practical men, and the pages of technical books are too valuable to record items of so little value and consequence.—T. C. Best, in *The Boiler Maker.*

DETERMINING THE COMPOSITION OF INDUSTRIAL GASES

Professor F. Haber has devised a method for ascertaining approximately the composition of a gas by means of its index of refraction. This, he finds, can be obtained with great accuracy by observing the displacement of the image which occurs on looking with a telescope at a distant object through a glass prism into which the gas is led. He uses an instrument made by Zeiss, of Jena, consisting of a prism telescope, a glass prism for the gas or air, and a mirror. The observer looks, not at a distant object, but at a luminous spot situated in the telescope itself. On looking into the instrument one sees a dark shadow, which falls upon a scale in a position corresponding to the composition of the gas in the prism. The method is simple, and has the advantage that the refractive index as compared with air, of a sample of gas, remains the same, provided any changes of temperature and pressure affect equally the sample and the air under comparison. If chimney gases be led through the prism, an increase of 0.9 per cent in the carbon dioxide causes the shadow to be displaced one division on the scale. The instrument is sensitive to 0.0000003 in the index of refraction, which corresponds to a change of 0.2 to 0.25 per cent of carbon dioxide in chimney gases. Methane (marsh gas), hydrogen, hydrochloric acid, and hydrocyanic acid can be determined in air with the same delicacy. In the case of acetylene or sulphuretted hydrogen the exactitude is twice as great; for sulphur dioxide two and one-half times as great, and for the vapors of pentane and benzine nearly ten times as great. Its sensitiveness has been proved quite satisfactory.—*Engineering.*

VACUUM MAKES A RECORD

A vacuum pressure of 400 pounds to the square inch drew practically every drop of blood from the body of W. D. Hunter, an engineer in one of the Chicago packing houses, and was the cause of a most unusual form of death. Hunter had gone to repair a tank used in the refrigerating process, had evidently slipped and one leg was drawn into the pipe, where it was held fast by the enormous suction. When discovered by his helper only a few minutes after the accident, the body was shriveled, absolutely white and cold. —*Popular Mechanics.*

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

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EVERYTHING PNEUMATIC

On another page of our present issue Mr. Tecumseh Swift calls attention to the simple fact that all the air we know of or have anything to do with is compressed air, and that therefore the title of our publication tacitly compels us to deal more or less with all air, whatever its pressure at any given time and whether or not its pressure has been increased by the mechanical reduction of its volume in passing through an air compressor of any type.

There can be no question as to the correctness of this dictum. All air *is* compressed. That is, all air, even free air, as we conveniently call it, is under more or less pressure. No air has any absolutely constant pressure. All air is constantly being compressed or re-expanded, and all the phenomena accompanying these operations are constantly recurring. With the changes of pressure are interdependent changes of volume, of temperature, of electric condition, all inviting study, with no promise of our ever reaching the limits of acquirable knowledge or of its practicable applicability in any direction.

The more that air is studied—always compressed air—the more wonderful is it shown to be. All organic life is dependent upon it, and this in more than one particular. Air is a chief instrument in maintaining temperatures within the possibilities of animal and vegetable existence; air is the chief agency in conveying and circulating the waters of the earth; air distributes its elementary gases, the one to sustain animal and the other vegetable life; air supports combustion, and all our "artificial" light and heat and power are derived from it; air assists in the diffusion of the illuminating and vivifying rays of the sun; air is a function in the operation of the electrical forces or nerve energies of the earth. None knows all of any of these things. These we can all be studying together, accumulating and contributing attainable knowledge each for all and all for each. We accept the hint of Mr. Tecumseh Swift and everything pertaining to air, and especially to the work it may be made to do for us, will be within our legitimate field. All who have anything new to tell of what air has done, is doing, or may be made to do, are invited to help us. We want Everything Pneumatic.

COMPRESSED AIR FOR LARGE HAMMERS

The valuable article which in the present issue we reprint from *The Engineer,* London, describing a compressed air operated hammer built by the Messrs. Pilkington, contains one sentence which should be specially noted: "The use of high air pressure for the operating of hand tools of the light percussion type is tending to familiarize works managers with the cleanliness and handiness of pneumatic power which must end in a great development in its uses." This is the constant story of the growing employment of compressed air in manufacturing. Continually one thing leads to another, or, rather, to two or three others, as Herbert Spencer says every cause is followed by more than one effect. The use of air for large hammers makes its way in the beginning by its handiness and readiness rather than by its absolute economy at the coal pile, but when air is used in sufficient quantity to make the saving of it eminently worth while then the economies are looked into and developed.

It is stated that seventeen of these hammers are being built for the Harland & Wolff shipyard where the air already is employed so extensively for the smaller pneumatic tools, riveters, chippers, caulkers, reamers, drills, etc. The air supply was there before the big air-operated hammers came, and now they are employed in such numbers that those which can show a saving in the use of air are chosen in preference to those original types which once satisfied if they only would go. The use of air thus developes the paradox that the more it is saved the more it is used. Where attention is given to the savings which are possible in the use of the air we may be very certain that the savings will be as sharply looked after in the compression and transmission of it, and the results cannot fail to be remunerative and gratifying.

TWO ENGINEERING RECORDS

Since the closing of our previous issue two notable events of interest to the entire engineering world call for mention. The first of these is the record-breaking, record-making trip of the new Cunard liner, Lusitania. Her achievement is the culmination of the labors of thousands of engineers, also of business organizers and pushers for a century, and it is impossible to assign the greatest credit to any one man, at least since Watt. All the world gets the benefit and all civilization shares the glory.

The second event, the fall of the Quebec bridge, it is sickening to think of. It is an item of the world's engineering record perhaps more exclusively than the other. We were expecting that here, too, would be an advanced record of successful achievement. Leading engineers planned the bridge, many engineers approved the plans, and if any did not approve or had fears for the strength or safety of the structure they were not heard of. Builders of long experience and with the most up-to-date facilities did the work. Presumably the best and most perfect materials were used, and tested, as far as the possibilities of testing extended. The production of the material was inspected and also its manipulation in the shop at every stage. The work was carefully planned in every detail, the erection as it proceeded was carefully noted and reported upon, the weather was not unpropitious, there was no high wind or earthquake shock, and before the erection was completed everything all at once fell straight down and four-score men were dashed to sudden death. The record is unique.

CORRESPONDENCE.

ALL AIR IS COMPRESSED AIR

Editor Compressed Air:

I have just been looking over two or three back numbers of Compressed Air and perhaps I may be permitted to say a word or two concerning my impressions. It seems to me that the publication has not fully realized its opportunity, and that on the other hand its readers have too tamely accepted it at its own valuation. While the restricted aim has been to deal only with the air which has passed through a compressor and been mechanically reduced in volume, the fact is that all the air with which we come in contact or concerning which we have any practical knowledge is compressed air. Some of it is compressed more and some of it less, but all is compressed by the weight of the air above it. If it were possible for us to ascend high enough we might reach the region of uncompressed air, air which had no weight of other air above it, but I don't know how we would be able to determine when we arrived at the top of the sea of air or how we would discover the line of demarcation between it and perfect vacuum. They say that men have gone in search of the North Pole who would not have been able to recognize its location if they had reached it.

If we went downward instead of upward from what we may call the normal level of compressed air we certainly would find the additional compression of the air one of the principal facts to deal with. Some time ago some foreign engineer was planning to bore a shaft down say a dozen miles through the integument of Mother Earth to see what he would find which is at present unknown. The cutting of the rocks and their successive removal was the simplest part of the job. The prohibitive condition which he ran against was the air pressure to be encountered. Why, when he got down to the depth spoken of he would have a pressure of a hundred pounds or so, and the compressed air apparatus of the human body is not adapted to deal with that, so he would have had to have contrived air locks to keep the air out long before he reached the bottom of the hole, and he would be bothered all the while with the air leaking in as fast as he could pump it out, so that how far it would be possible to penetrate toward the center of the earth has not been settled to this day, and to a great extent on account of the indeterminability of the compressed air factor.

The fact is that we are born into compressed air. Our first breath of life and our last is of compressed air, and without air suitably compressed we could not live a minute. A publication, then, which proposes to treat of compressed air has all the human race for its prospective constituency, and it should not be satisfied until it, by deserving, has secured a considerable portion of the total of readers to which it is legitimately entitled. It is to be hoped that the conducters of Compressed Air will not let up in their endeavors to give us the latest and the completest information concerning the artificial compression of air and the various and widening employment of air so compressed, but it should remember that air so compressed is less than a drop in the bucket compared with the air which is compressed by gravity, that the latter is charged with the maintenance of life and the sustenance of every activity, that all our life long we may be hearing of its uses and its wonders, with still more continually before us yet unknown. The legitimate business of Compressed Air should be to deal with *Everything Pneumatic.*

Tecumseh Swift.

QUESTIONS AND ANSWERS

It must be obvious that the Editor cannot undertake to answer questions by mail. Questions presumably of interest to readers will be answered here as far as possible, and such questions are invited.

W. M. S., Batson, Texas.—*Q.*: If a tank holding 100 cubic feet was filled with air to a gage pressure of 100 pounds and another tank of the same size was connected closely to it, a valve being opened and admitting air from the first into the second until the pressures and volumes were equal, would the second tank then have in it 50 per cent of the first one? That is to say, would it have 50 per cent of the original working energy? If not, where would the difference of energy go?

A.: Having 100 cubic feet of air at 100 pounds gage pressure, or $100 + 14.7 = 114.7$ pounds absolute pressure, the volume of free air contained in the first tank would be $114.7 \div 14.7 = 7.8 \times 100$, or 780 cubic feet. The contents of the second tank being 100 cubic feet of free air to begin with, the total free air contents of the two tanks will be $780 + 100 = 880$ cubic feet. The absolute pressure of the air when equalized in the two tanks, after the normal temperature is resumed, will be

$$200 : 800 :: 14.7 : 64.68,$$

and the gage pressure therefore will be $64.68 - 14.7 = 48.98$ pounds.

Now the question seems to be, if put into an approximately practical form: Will 200 cubic feet of air at 49.98 pounds, gage, be capable of doing as much work as 100 cubic feet at 100 pounds? Referring to Table VI., page 108, Richards' Compressed Air, we find that air at 100 pounds used in an engine, cut off at one-quarter stroke and expanding adiabatically down to 1.33 pounds, which is near enough to atmosphere, will have a mean effective pressure for the stroke of 44.19 pounds. Then with a piston area of 1 square foot and a stroke of 1 foot the work per stroke will be 44.19 foot-pounds, and as but ¼ cubic foot of air will be used per stroke there will be $100 \div \frac{1}{4} = 400$ strokes of work, or $44.19 \times 400 = 17.676$ foot-pounds of work for the 100 cubic feet at 100 pounds.

From the same table VI., but on page 103, we find that air at 50 pounds cut off at three-eighths stroke will have practically the same pressure at the end of the stroke as in the previous case, 1.34 pounds, and will have a mean effective pressure for the whole stroke of 29.07 pounds. Then, with a piston area of 1 square foot and a stroke of 1 foot, as before, the work done per stroke will be 29.07 foot-pounds, and as but ⅜ cubic foot of air will be used per stroke the total number of strokes will be $200 \div \frac{3}{8} = 533$ strokes of work, or $29.07 \times 533 = 15.494.31$ foot-pounds of work for the 200 cubic feet at 50 pounds. It would be a little less than this, as we find the pressure to be a little less than 50 pounds in the two tanks. The work done here is thus about 13 per cent less than that done by the 100 cubic feet at 100 pounds.

It is scarcely necessary to inquire here where the energy was dissipated. If the air at 100 pounds had been discharged into the atmosphere or allowed to expand all the way down to atmosphere, of course all the available energy would have been lost. The loss would have begun with the beginning of the re-expansion and some of the loss would therefore have occurred, as it did occur, before the pressure of 50 pounds was reached.

W. G. L., Los Angeles, Cal.—*Q.*: Can you tell us what the saving is, in percentage of efficiency, in returning the air to the inlet pipe of the compressor in place of exhausting into the atmosphere in using the displacement system of pumping by compressed air?

A.: It is understood that what is wanted is a comparison of the efficiency of a plain pneumatic displacement pump with that of a properly proportioned return-air pumping system, both working under similar conditions. It will be seen that in a question of this kind there are several particulars to be considered. The lift or head against which the water is pumped is important. Generally speaking, return-air pumps are not employed for lifts of less than 50 feet, because the percentage of loss in a plain displacement pump increases with the head against which the pump acts, or, in other words, the loss due to the escape of compressed air into the atmosphere where only low pressures are required is not so serious as it must be under higher lifts, the greater loss being because the air *is not used expansively*. As the loss in efficiency in using any plain displacement pump increases as the head, it follows that the percentage of gain in favor of a return-air system is greater when pumping against a head of 200 feet than it would be in lifting the water 100 feet.

The depth of water over the tanks (amount of submergence possible) or the suction lift necessary to draw the water into the tanks, if it is necessary to place the tanks above the water level, are conditions which modify the efficiency of a return-air system. This particular point may be illustrated by taking the following conditions: Lift of water, 150 feet; pipe volume, 0.4 of tank. Then with a suction lift of 10 feet the efficiency would be 43 per cent; with the tanks just covered, 48 per cent, and with a submergence of 10 feet, 51 per cent. Finally, the greatest loss in a return-air system is caused by the drop in pressure due to the expansion in the low-pressure pipe after switching; therefore, the ratio of volume of air pipe to volume of tank must be kept as low as possible.

To state something definite in the matter of relative efficiencies, the best we can do is to make a comparison, taking some common, ordinary case, say, a lift of 150 feet. The ultimate efficiency of a properly proportioned return-air system, measured from the indicated horse-power of the steam cylinder of the compressor to the net work in water lifted, will be from 50 to 55 per cent; and, as against this, the best efficiency of a plain displacement pump will be from 24 to 27 per cent.

THE MINE LOCOMOTIVE EXPLOSION

In our July issue we gave some account of the explosion of a compressed air locomotive with fatal results in Colliery No. 14 of the Pennsylvania Coal Company. We suggested that the initial cause of the explosion was the formation of an explosive mixture of air and oily vapor and then the ignition of the same caused by a sufficiently high temperature at some point.

The following letter, appearing originally in *Mines and Minerals*, offers additional suggestions in the same line, giving also a variety of valuable information concerning other accidents of the same character. We print the letter in full:

"Regarding the explosion of the compressed-air locomotive, there is no doubt in my mind but that the compressed air contained in the tank had a sufficient admixture of an explosive nature to become detonated, and consequently would be so suddenly expanded by heat that safety valves or other vents would not even have time to respond or move from their seats before the tank was exploded. The volatile properties of the oil used in the compressor could furnish the necessary amount of carbon to form a combustible mixture in the pipes, as well as in the locomotive. We know of numerous instances where these explosions have occurred, but how the ignition or detonation of the gas occurs has never been explained, satisfactorily, at least.

"An air receiver exploded out in Oak Park, Ill., several years ago, and there was no fire anywhere near it at the time it occurred. Another explosion of this kind occurred at the power house at Quinnessec Falls, near Iron Mountain, Mich., where the air is compressed by water power, blowing up the receiver and setting the building on fire. There was no fire in the building at the time, no boiler being used. A similar accident occurred at the Lumaghi Coal Company's mine, near St. Louis, where a receiver, located in the mine, a long distance from the engine house, exploded. The explosion of the receiver in the compressor plant at Quinnessec Falls proves that it was accomplished by heat, as the combustible gas set the building on fire after the explosion. The duration of the flame would depend on the amount of carbon to a given quantity of air and seemingly there was a sufficient amount of it in this case to support the flame a sufficient length of time after the receiver exploded to set the building on fire.

"The receiver at Oak Park, of the Lumaghi Coal Company, and the pneumatic locomotive in the present instance did not show the presence of fire, but the percentage of carbon in the mixture was probably much less than in the Quinnessec compressor case, not even sufficient to support the flame after the explosion had occurred, yet sufficient to heat the mass of compressed air to a sufficiently high temperature to cause the tank to explode. While I am not in a position to prove it definitely, there is no doubt in my mind but that these explosions are caused by detonation, and not by direct ignition by fire.

"In all the above cases the fragments proved that explosions had taken place, inasmuch as the plates were shattered into, comparatively speaking, small and irregularly shaped pieces. If these receivers and tanks had become ruptured on account of the pressure being greater than the material could stand the pieces would be much larger and the receiver or tank would be ruptured in two or three places like a bursted boiler. With reference to mixtures of atmospheric air and gases and the duration of the flame after explosion, I will relate two cases that I had an opportunity to observe a few years ago.

"Several car loads of hay were maliciously ignited in the freight yards of the C., M. and St. P. R. R., a short distance from our works. On the adjoining track was located a large tank of crude petroleum. The heat from the burning hay heated the oil tank until the pressure became sufficiently great to partially rupture the top of the tank and blow the dome, located near the center of the tank, entirely off. The explosion of the heated liquid oil, of course, was instantaneous as soon as the rupture of the tank exposed it to the atmosphere. The explosion, however, only partially consumed the oil, but its force was sufficient to thoroughly diffuse or disseminate the entire mass. It shot into the air, I should say, about 1,000 feet. I know this from my personal observation, as I happened to see the occurrence, watching it from a safe distance. So much carbon was diffused through a small amount of atmospheric air that the combustion was only partially accomplished. Tongues of flame were shooting out from the huge black cloud considerable distances in all directions, proving that there was not a sufficient amount of oxygen in the atmosphere immediately surrounding the mass for the large amount of carbon contained in the diffused oil to cause instantaneous combustion. The mass continued to burn in the air more gradually than if the necessary amount of oxygen could be immediately transmitted to it by the circulation of the atmosphere through the combustible gas. It burned a sufficient length of time to ignite any inflammable material with which it came in contact, the action of the explosion being the same as in the case of the Quinnessec power house when the tank exploded, containing rich combustible gas.

"The second case was an explosion of gasoline, which, of course, is much lighter and much more volatile than the crude petroleum. It mingled with the atmosphere instantaneously. The explosion was as sudden and nearly as violent as the explosion of smokeless powder, neither smoke nor flame being visible.

"In the latter case there was nothing to indicate that any flame had been produced by the explosion, as nothing was blackened, or showed the effects of heat in any way. I am merely referring to these two instances to show that, while an air tank might be exploded without the fragments showing any evidence of heat or fire, as in the latter case, the former case showed plainly the presence of both. So that, if an air tank does explode without leaving behind any trace of heat or smoke, it does not necessarily imply that it was not an explosion due to heat.

"S. T. Nelson,
"Supt. Chicago Works, Sullivan Mach. Co."

TRADE PUBLICATIONS

Butt-Welding by the Thermit Process, Goldschmidt Thermit Company, 90 West street, New York; 12 pages, 6x9.—This pamphlet describes the process and the apparatus employed in the welding of pipes and rods, with price lists and other details.

Record of Recent Construction, No. 63, Baldwin Locomotive Works, Philadelphia; 32 pages, 6x9 inches.—The frontispiece shows the exhibit at the Jamestown Exposition and full page half-tones are given of 14 different types of locomotives with the principal dimensions of each in English and French.

Victor Air Compressor, Victor Electric Company, 55 Market Street, Chicago. This leaflet describes a small vertical electric-driven air compressor built by the company. The pistons are 2-inch diameter and 2½-inch stroke. The outfit is adapted to the use of physicians, dentists, air-brush artists, etc.

Tobin Bronze, Ansonia Brass and Copper Company, 99 John Street, New York; 40 pages, 4x7 inches, illustrated.—This publication contains a wide reach of information concerning the valuable material represented, with numerous testimonials of the highest character. The accounts given of the applications of Tobin Bronze in marine architecture and engineering are specially interesting.

Power Plant Equipment, Schuette and Koerting Company, Philadelphia; 24 pages, 11x8 inches.—Enumerating and illustrating the Koerting injector, the eductor condenser, the Koerting spray nozzles, automatic stop check valves, free exhaust valves, quick closing balanced trip valves and numerous other standard valves and devices manufactured by the company.

Economical Machinery for the Coal Mine, Ingersoll-Rand Company, 11 Broadway, New York; form 53A, 24 pages 3¼x5½, 15 half-tones.—This handy leaflet gives a variety of information concerning the various machines for the coal mine manufactured by this company. Ten entirely distinct lines of apparatus are treated of, all up-to-date and of the highest efficiency in their respective classes.

A Complete and Modern Line of Brass and Iron Specialties is shown in the Catalog of The William Powell Company, of Cincinnati. This catalog presents their line in a most complete and practical manner, giving dimensions of every article for which a dimension may be required, and explaining in detail the merits of their well-known specialties.

Gauges, Wells Bro.'s Company, Greenfield, Mass; 54 pages, 4⅞x7⅞ inches; numerous illustrations and tables.—The gauges and micrometers described are mostly for measuring screw-threads on pipes, bolts and nuts, etc. This class of tools, and these tools of this class, are doing much in the promotion of precise workmanship and the fixing of accurate standards, these particulars being paramount not only in the production of reliably interchangeable parts but also in reduction of cost of manufacture.

Technical Literature, which with its June issue completed its first half yearly volume, purposes to review and index the most important articles in the various technical publications, American and foreign, abstracting and reproducing the most prominent, suggestive and informing. Technical journals, books and proceedings are now so voluminous, and collectively so costly, that few have the means and still fewer the time to go through them, and yet a knowledge of them is very essential to the progressive man whatever his interests. *Technical Literature* is a careful and thorough collector and sifter, and is doing a work the results of which should not fail to be appreciated and appropriated.

QUICK WORK ON A BIG FLY WHEEL

The C. & G. Cooper Company of Mount Vernon, Ohio, have just completed the installation of a large flywheel for the Youngstown Iron and Steel Roofing Company, Youngstown, Ohio, in record time. The wheel was built to replace one which burst August 5th. This old wheel had been in service a great many years, and with the engine was built in Providence. The Youngstown Iron and Steel Roofing Company gave the order for the new wheel on August 9th, with the understanding that it was to be shipped in twenty-six days.

The wheel is 24 feet 8 inches in diameter and weighs 90,000 pounds. It was designed, cast, machined and shipped complete from the works of the C. & G. Cooper Company on August 31st, or in eighteen working days. This anticipated the promised delivery about five days. It was delivered to the roofing company Sunday, September 1st, erected and running by Tuesday, September 3d. The wheel is of the square-rim type, made in halves, and held together at the rim by double-headed, countersunk tees of fagoted iron, and at the hub by four 4-inch bolts, and also double-headed tees. The arms are oval shape, and ten in number. The joints of the wheel are fitted with 3-inch tool steel dowels, which serve the double purpose of insuring a true joint and resisting any centrifugal strains by the shearing strength of the pins.

NOTES

The interesting article in our September issue, "Recent Practice in Tunnel Driving," was condensed from an article in *Mine and Quarry*, and not in the publication to which we credited it.

The largest mine ever exploded in Europe was sprung recently nearly 5,000 feet above sea level. Eight tons of a special explosive, having a power equivalent to twenty-four tons of gunpowder, was employed, and the whole of the fore part of Mount Maggiore, near Carrara, consisting entirely of splendid white marble, was blown away. It is calculated that half a million tons of marble was displaced.

Practical use of air as an electrical insulator is made in a method patented by Prof. H. J. Ryan. The conductors have ordinary minor insulation and are inclosed in a compartment containing air sufficiently compressed to afford the requisite dielectric strength. It is estimated that at 588 pounds per square inch air should be as good as linseed oil bond paper; at 265 pounds as good as nicanite cloth, and at 118 pounds as good as melted paraffine.

The new coal shaft being opened at Atchison, Kan., is the deepest bituminous coal shaft in the United States. It works a coal vein at a depth of 1,126 feet. The hole was sunk with a diamond drill and the entire core, with the exception of some coal removed for analysis, is preserved at the State University. In all eighteen beds of coal were penetrated, and of this coal 2 feet is unquestionably workable. The total cost of drilling was about $4,700, roughly at $3.50 per foot.

The walls of the Acropolis at Baalbek are truly called Cyclopean. The famous Trilithon, the largest stones ever used in building, measure respectively 65, 64, and 63 feet in length, each block weighing about 750 tons. How these huge masses were accurately placed in position 20 feet above the ground is a problem which modern science, with all its appliances, leaves yet unsolved. Above them are the Arab fortifications. The quarries whence these gigantic materials were obtained are among the most interesting features of Baalbek. Here may still be seen the method of work of the ancient quarrymen, stones vertically hewn lying almost ready to the hand of the builder. One of these stones, to which the Arabs give the name of Hajar-el-Houbls, measures 69 feet in length, and weighs 915 tons. M. de Sauley calculates it would take the united efforts of 40,000 men to put this huge block in motion. This quarry is now used as a necropolis by the inhabitants of Baalbek.

At the north shaft of El Oro mine, Mexico, the discarded steam cylinders of the hoist, which is now operated by electric current, are used in a novel way for speed regulation. The new motor is a 120 horse-power variable speed induction unit coupled directly to the pinion shaft of the hoist. In lowering a cage down the shaft the pistons of the old engine are made to compress air in the cylinders so that by opening or closing a valve a fine speed regulation may be obtained.

The French Government has approved the use of submarine signalling, and has ordered submarine signal bells actuated by pneumatic power to be placed at the ends of the piers at Calais, Boulogne, and Havre, and a submarine signal buoy to be placed for trial off Havre. A submarine signal bell has been fitted to the Sandette lightship, off Dunkirk, for some time. When these bells are working there will be practically a continuous system of submarine signals from Havre to the Elbe.

That remarkable instrument, the barometer, is subject to curious fluctuations, apart from the ordinary steady rise and fall, little undulations caused by sudden changes, and by such simple things as the presence of a cloud over the locality. These oscillations are so minute that nobody ever thought they could be indicated on a barograph—the chart which records the movements of the mercurial column. Nobody, that is to say, but Mr. Dines, who, at the instigation of Dr. Shaw, has invented a strange piece of mechanism, which actually does register these minute variations—the "embroidery of the barometric chart," as the director calls them—and so produce a microbarograph.

Rock breaking on the Suez Canal has been done since 1902 with Lobnitz chiseling machines having 13-ton rams. The average height of fall of these rams is from 5 to 10 feet. On the average 132 blows are delivered per hour of effective rock breaking, but as the passage of ships requires the rock-breaking barge to be drawn aside 30 per cent of the time, the actual work of the barge is 83 blows per hour of work paid to the crew. The average thickness of the rock bed shattered is 2 feet 7½ inches, and it requires about 5.4 blows per cubic yard to shatter the rock. There is considerable range in the cost of the work, but it averages $0.33 per cubic yard, exclusive of general charges. This also does not include the cost of dredging the rock.

Air compressors should be supplied with the coolest and purest air obtainable. For this reason the intake pipe should be extended outside the compressor building. If there be a leak leading from the cylinder to the intake pipe which permits some of the compressed and heated air to return to the intake, there is danger of the compressor becoming very hot and either *exploding the jacket*, or setting fire to any oil that may be present in either cylinder, receiver, or pipe. This burning oil would be forced into the main line of the system and into the mine workings through the exhaust of the drills, an unhealthy if not dangerous thing for the workmen. In some instances of this kind the men have been overcome with carbonic acid gas. *This is known as the inflaming of compressors.—Los Angeles Paper.*

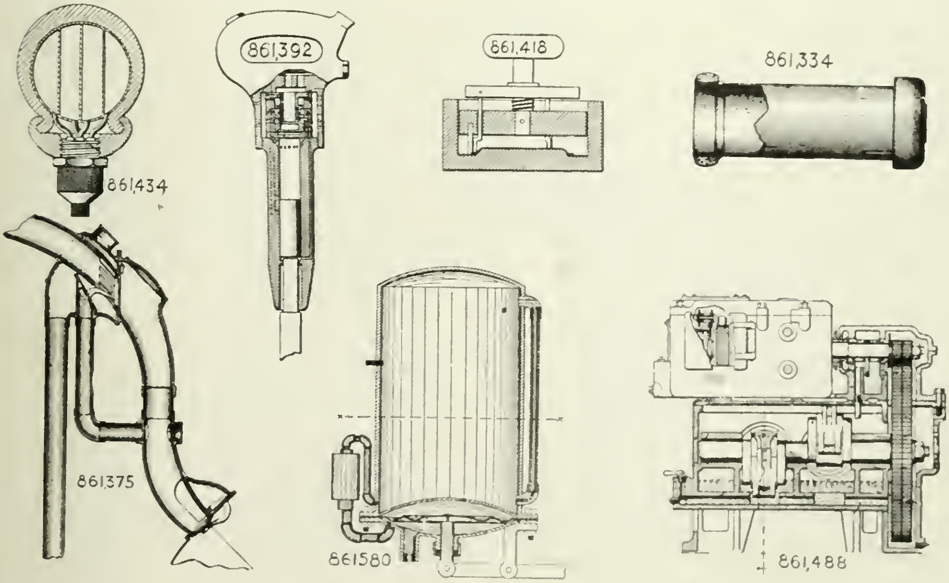
Attempts are to be made to salve from the wreck of H. M. S. "Lutine," which sank off the coast of Holland some one hundred and ten years ago, about £400,000 of bullion, and orders have been given out for the necessary apparatus. The most important part of the equipment will be what might be called an inverted diving bell. It will consist of a long telescopic tube, supported at the top by a barge and terminating at the bottom in a large closed chamber which will be lowered on to the wreck. From this chamber the salving operations will be conducted through air locks. When the mud and sand which have accumulated over and in the wreck have been removed the interior will be cleared by compressed air. It is then hoped that divers will be able to recover the treasure.

The drilling of bolt holes in partially green concrete is a tedious process, owing largely to the frequent wedging of the drill. One contractor seems to have hit upon a simple method of drilling these holes without undergoing the delay incident to wedging. He uses a compressed air drill hung in the guides of a small pile-driver frame, the drill occupying the same position as would the hammer in pile driving. The drill was suspended by a wire rope, and raised or lowered by means of a hand windlass. One advantage of this arrangement was that a longer drill could be used than with the ordinary tripod outfit. A small metal pipe was carried with the drill into the hole, and through this water was forced under a heavy pressure, carrying off the chips, and thus preventing all tendency to wedge. Many such holes have been bored in partially green concrete to a depth of over six feet.—*Engineering Contracting.*

A curious story comes from Germany of the successful opening of a safe by a burglar by means of an oxygen-acetylene blow-pipe. The burglar cut a hole through the ceiling above the safe and lowered a complete blow-pipe apparatus, including an acetylene generator and two cylinders of compressed oxygen through the hole, and by its aid he melted away enough of the door to make the contents of the safe accessible—a tent of heavy blankets having been first built around the safe to prevent the operation being visible.

Protection from such a method of safe cracking by any possible improvement on existing lines of construction would seem to be impossible, and the emergency has called out the suggestion that protection can be obtained by means of apparatus which will liberate deadly fumes whenever the safe is tampered with. Among these is a suggestion for an apparatus which would liberate the fumes of prussic acid, and other suggestions less dangerous to innocent parties.—*American Machinist.*

The sinking of the deepest mineral bore in Great Britain has just been completed at Cameron Bridge. The bore has been put down to the depth of 756 fathoms, or 4,536 feet, and the hurlet or mountain limestone seam, the objective, has been reached. Great difficulties had to be surmounted before the bore reached the lowest point, and these obstacles were responsible for the operation being prolonged for several years. The bore measured 8 inches at the surface and 1¾ inches at the bottom, and the lower coal seams of the East of Fife were satisfactorily proved. The seams of the western district of the county were also pierced, and it is understood they were discovered to be of such thickness as would make working profitable. Mining at a depth of three-quarters of a mile has not yet become an engineering possibility, but within ten years the depth of coal mines has been increased by 100 fathoms, and it is quite probable that the day is not so far distant when the seams passed through could be worked. So far as is known, the next deepest bore in the country was that put down at Gilmerton. Here the depth reached was 500 fathoms. The Scottish Geological Society has taken much interest in the work at Cameron Bridge, and it is stated that an instrument is to be put down to ascertain the temperature at the bottom of the bore.



PNEUMATIC PATENTS, JULY 30

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

July 30.

861,270. PNEUMATIC DENTAL CEMENT-INJECTOR. Henry L. Cruttenden, Northfield, Minn.

861,334. CARRIER FOR PNEUMATIC-DESPATCH TUBES. Edward G. Thomas, New York, N. Y.

861,375. PNEUMATIC-DESPATCH-TUBE APPARATUS. Isaac W. Litchfield, Boston, Mass.

861,392. PNEUMATIC TOOL. Harold R. Prindle and John U. Adolph, Philadelphia, Pa.

861,418. APPARATUS FOR MAKING PNEUMATIC DIAPHRAGMS. Morris S. Wright, Worcester, Mass.

861,434. PNEUMATIC TIRE. Thomas J. Chatham and James S. Holliday, Turlock, Cal.

861,488. MOTOR-COMPRESSOR. William L. Waters, Milwaukee, Wis., assignor to National Brake and Electric Company, Milwaukee, Wis.

861,580. HYDROPNEUMATIC ENGINE. Lewis W. Eggleston, Appleton, Wis.

862,060. PNEUMATIC OPERATING DEVICE FOR MUSICAL INSTRUMENTS AND MUSICAL-INSTRUMENT PLAYERS. Benjamin S. Dean, San Francisco, Cal.

862,119. PNEUMATIC RENOVATOR. Frank T. Snyder, St. Louis, Mo.

August 6.

862,160. RELIEF MECHANISM FOR COMPRESSORS. Ebenezer Hill and Henry P. Morgan, Norwalk, Conn.

862,164. PNEUMATIC PAINT-TOOL. Edwin F. Hulbert, Kenosha, Wis.

862,333. METHOD OF CREATING A VACUUM. Peter C. Hewitt, New York, N. Y.

862,342. PNEUMATIC-DESPATCH-TUBE APPARATUS. Isaac W. Litchfield, Boston, Mass.

862,404. ROTARY PUMP, EXHAUSTER, AND BLOWER, &c. Frederick Lamplough, London, England.

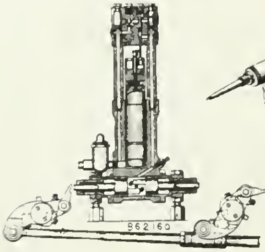
862,429. AUTOPNEUMATIC MUSIC-PLAYING INSTRUMENT. Frank C. White, Meriden, Conn.

862,492. TRIPLE VALVE FOR AIR-BRAKES. William B. Mann, Baltimore, Md.

862,541. HUMIDFIER. Frank B. Comins, Sharon, Mass.

862,564. GAS-COMPRESSOR. Robert O. Klatte, Hamburg, Germany.

862,601. PNEUMATIC-TUBE SYSTEM. Birney C. Batcheller, Philadelphia, Pa.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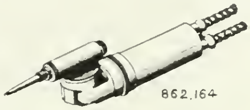
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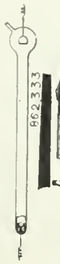
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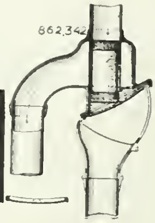
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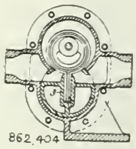
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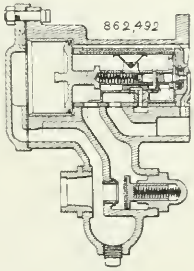
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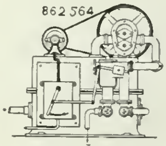
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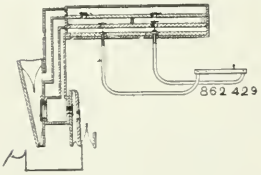
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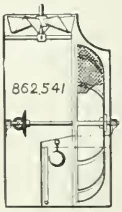
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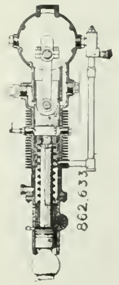
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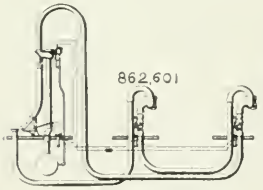
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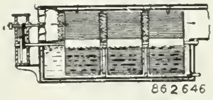
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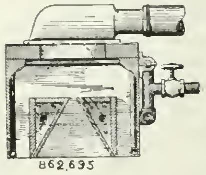
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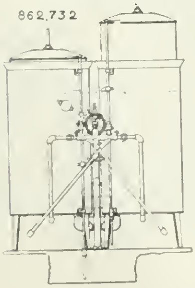
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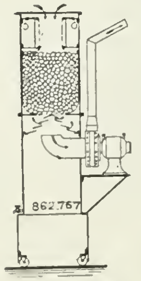
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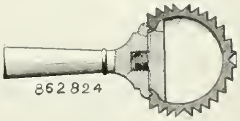
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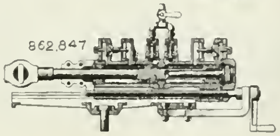
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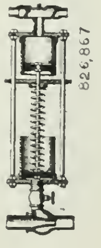
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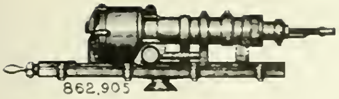
PNEUMATIC PATENTS, AUGUST 6.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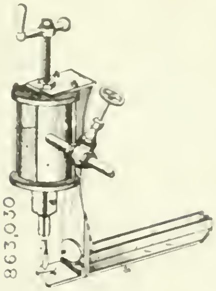
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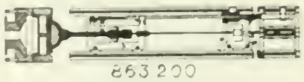
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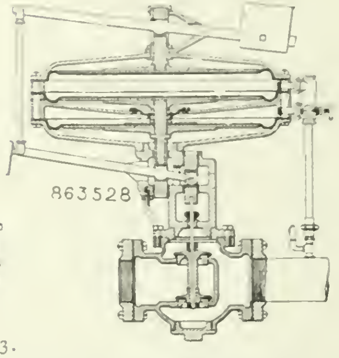
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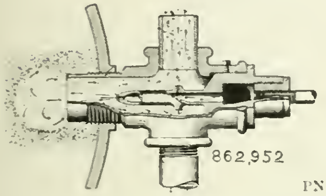
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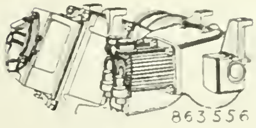
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PNEUMATIC PATENTS, AUGUST 13.

862,646. AIR AND WATER COOLING APPARATUS. John Little, Camberwell, near Melbourne, Victoria, Australia.

862,653. ROCK-DRILL. Howard A. Pedrick and Charles A. Smith, Philadelphia, Pa.

862,695. PNEUMATIC CARPET-CLEANING DEVICE. Charles S. Baldwin, San Francisco, Cal.

862,696. GOVERNING MECHANISM FOR PNEUMATIC-TUBE SYSTEMS. Birney C. Batcheller, Philadelphia, Pa.

862,767. AIR-COOLING APPARATUS. Otto Sterkel, Ravensburg, Germany.

862,732. APPARATUS FOR SUPPLYING AIR AND REGULATING PRESSURE THEREOF. Edwin A. Hall, Hyde Park, Mass.

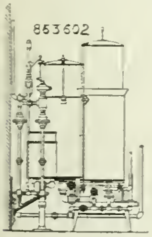
862,824. PNEUMATIC CLEANING DEVICE. Lewis O. Howell, Philadelphia, Pa.

862,847. GAS-ACTUATED ROCK-DRILL. John V. Rice, Jr., Edgewater Park, N. J.

862,867. PNEUMATIC PUMPING APPARATUS. Lewis W. Eggleston, Appleton, Wis.

August 13.

862,905. PNEUMATIC DRILL. Frederick Hart, Poughkeepsie, N. Y.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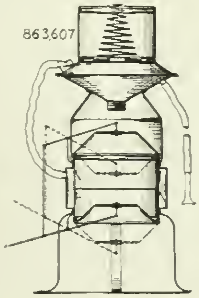
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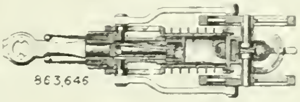
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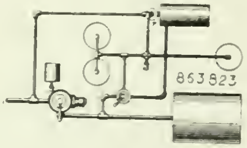
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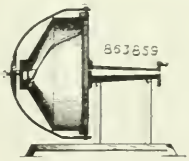
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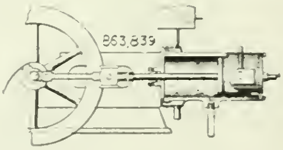
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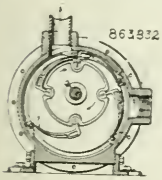
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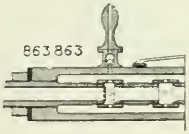
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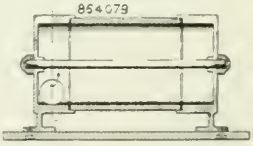
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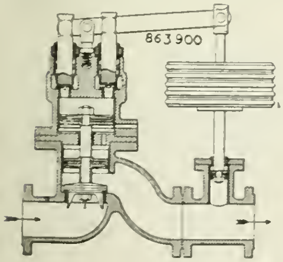
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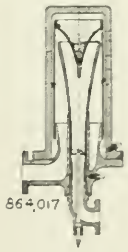
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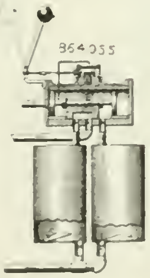
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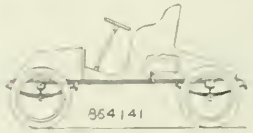
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PNEUMATIC PATENTS AUGUST 20.

862,931. PNEUMATIC DEVICE FOR OPERATING GAS-VALVES. Richard N. Oakman, Brooklyn, N. Y.

862,952. PNEUMATIC TRACK-SANDER. John H. Watters, Augusta, Ga.

863,030. PORTABLE AIR-DRILL. Swan P. Johnson, Clinton, Iowa.

863,200. AIR-REGULATING DEVICE FOR GLASS-DRAWING MACHINES. Ira A. Milliron, Franklin, Pa.

863,528. FLUID-PRESSURE REGULATOR. Louis B. Fulton, Pittsburg, Pa.

863,556. MOTOR-DRIVEN AIR COMPRESSOR Edward D. Priest and Einar J. Bring, Schenectady, N. Y.

August 20.

863,602. AIR-SUPPLYING AND PRESSURE-REGULATING MEANS FOR AIR AND GAS MIXING APPARATUS. Edwin A. Hall, Hyde Park, Mass.

863,607. DUST-ASPIRATING APPARATUS. Christian F. Holder, Metzingen, Germany.

863,646. HYDROCARBON ROCK-DRILL. John V. Rice, Jr., Edgewater Park, N. J.

863,823. COMBINED AUTOMATIC AND STRAIGHT AIR BRAKE. Edward A. Wright, Edgewood Park, Pa.

863,832. POSITIVE-PRESSURE BLOWER. Francis P. Boland, Providence, R. I.

863,839. POWER APPARATUS. William W. Flickinger, Bradford, Pa.

Claim.—In a combination in an air-compressing engine, a cylinder, a piston, means for admitting motive fluid to one end of the cylinder air inlet and discharge means for the other end whereby the air is drawn in on one stroke and discharged on the reverse stroke, means for destroying the partial vacuum as the piston reaches the end of its suction stroke, said means consisting of a port so located as to be uncovered as the piston completes its stroke in either direction, thereby acting on one stroke as an exhaust port and on the opposite stroke as an air inlet port, substantially as described.

863,859. PNEUMATIC BUTTER-SEPARATOR. La Fayette Lillard, Bootjack, Cal.

863,863. APPARATUS FOR CREATING AND MAINTAINING A VACUUM. Albert Manvers and Henry Phillips, Sydney, New South Wales, Australia.

863,900. APPARATUS FOR REGULATING PRESSURE IN PIPES. John B. Broadhead, Wellholme, Brighouse, England.

864,017. PRODUCTION OF FLUID FOR POWER. Francesco Miller, Turin, Italy.

864,055. COMPRESSED-AIR WATER-ELEVATOR. Frank Allison, Chattanooga, Tenn.

864,078. AIR-PURIFYING APPARATUS. George Clements and James M. Hostler, Chicago, Ill.

864,141. COMPRESSED-AIR-CUSHION MECHANISM FOR AUTOMOBILES. Thomas F. Scott, Everett, Mass.

August 27.

864,220. PNEUMATIC ENGINE. Edwin D. Ackerman, New York, and Charles E. Clinton and Robert N. Eltom, Corona, N. Y.

864,270. DRILL-CHUCK FOR USE ON HAMMER ROCK-DRILLS. Albert L. Stephens and Thomas McGrath, Silver Plume, Colo.

864,284. PNEUMATIC OIL-CAN. John S. Arnott and Eugene L. Arnott, Greenfield, Ohio.

864,339. AIR-PUMP AND AUTOMATIC PRESSURE-REGULATOR THEREFOR. Gottfried Schmidt, Hazleton, Pa.

864,344. FLUID-PRESSURE SYSTEM. Samuel B. Stewart, Jr., Schenectary, N. Y.

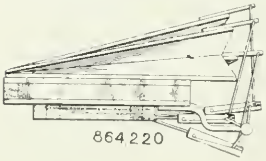
864,471. SAND-BLAST APPARATUS. William H. Kelly, San Francisco, Cal.

864,494. PNEUMATIC TOOL. Wilber H. Van Sickel, Philadelphia, Pa.

864,551. PNEUMATIC SYSTEM FOR CONTROL OF WINDOWS. Joseph B. McKeown, Union Hill, N. J.

864,618. PIPE-COUPLING. Louis V. Deloche, Monongahela, Pa.

864,677. HYDRAULIC AIR-COMPRESSOR. Jett E. Nash, Cheyenne, Wyo.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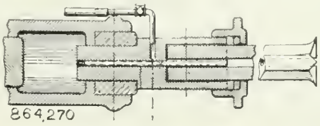
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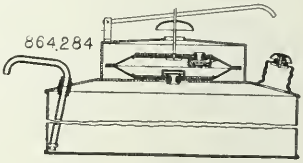
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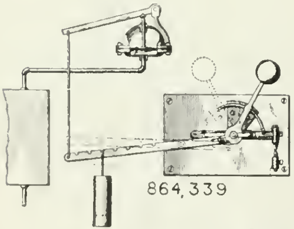
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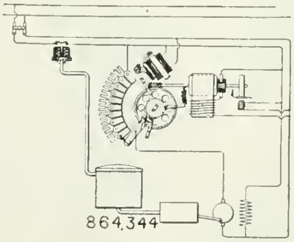
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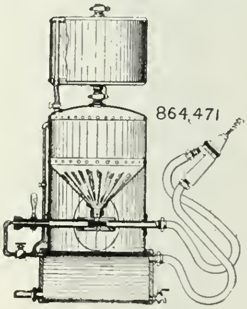
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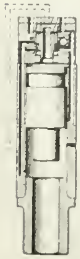
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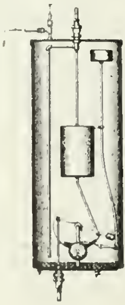
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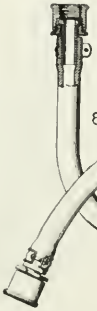
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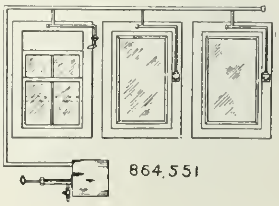
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PNEUMATIC PATENTS, AUGUST 27.

COMPRESSED AIR
AND EVERYTHING PNEUMATIC

Vol. XII NOVEMBER, 1907 No. 9

THE ELECTRIC-AIR DRILL*

By William L. Saunders.

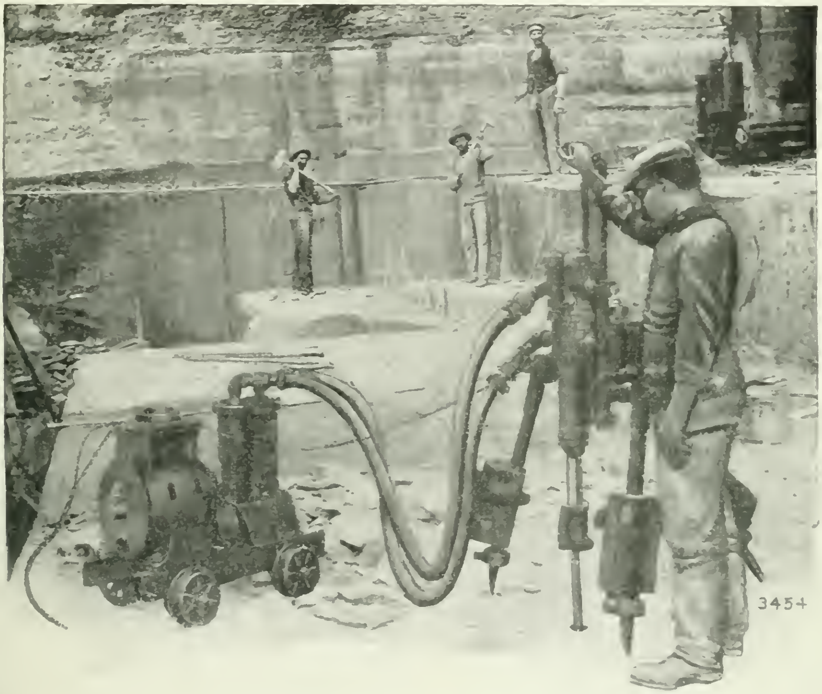

FIG. 1. ELECTRIC AIR DRILL IN A QUARRY.

Many members of the Institute, who participated in the visit made, during the Bethlehem meeting of February, 1906, to the shops of the Ingersoll-Rand Company, at Phillipsburg, N. J., inspected with interest the new Electric-Air drill, which the company had set up for the purpose of showing it in actual operation to American mining engineers. At the request of the Secretary of the Institute, I promised at that time to prepare a paper for our *Transactions*, describing the construction and advantages of the machine. But such a paper would then necessarily have contained much that was only expected or claimed by the designers and manufacturers of the drill, and not yet incontrovertibly proved by varied and long-continued practice. However moderate such statements might have been, they would have given inevitably to the paper, to some extent at least, the air of a prospectus, rather than of a technical contribution. I therefore decided, with the Secretary's approval, to postpone the writing of the promised paper until it could set forth the results of adequate actual practice, as well as the latest details of construction, etc., based upon practical experience. That period has now arrived. The Electric-Air drill has been exhaustively tested in the field, under varied and arduous conditions and upon the hardest rocks. It is now fairly in the field; its merits and performances are matters of unimpeachable record, and its place among established competitors can be definitely determined.

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*Presented at the Toronto meeting, July, 1907, and reprinted from advance sheets of the Bi-monthly Bulletin of the American Institute of Mining Engineers for November, 1907.

As a representative of the Ingersoll-Rand Company, as well as a member of the Institute, I may be permitted to add that my company, being largely interested in the manufacture of air compressors and machinery driven by compressed air, has no desire to injure its own business by claiming for this new machine that it should immediately supersede all existing applications of pneumatic transmission of power for drilling. On the other hand, if we had not satisfied ourselves that it has proved itself the best for given conditions, the company would not have risked its reputation by introducing it, and I, as a member of the Institute, would not have written this paper.

In former contributions I have discussed the use of compressed air, and opposed, to some extent, the claims of the advocates of electrical power-transmission in mining. I need not now retract any opinion thus declared. Many features of electrical transmission are undoubtedly convenient and economical; but the direct application of the electric current in rock-drilling has long been a baffling problem; of which, in my judgment, the machine here described has furnished the first, and thus far the only, satisfactory solution, by combining the acknowledged advantages of air-driven percussion with the acknowledged advantages of electric power-transmission, while avoiding the acknowledged disadvantages of both systems.

The Electric-Air drill is correctly designated; it is not an electric drill but an air drill, more completely an air drill than any other in existence, because it can be driven by air only and not like other air drills by steam also. Yet, while it is thus distinctly air operated the power of transmission is electric, and the sole connection of the drill with the power-house is made by means of the electric wire, air compressors and pipe lines being entirely superseded.

Fig. 1 gives a general idea of the apparatus. It shows a rock drill which at first glance looks quite like the familiar air or steam driven drill, mounted in the usual way and doing the same kind of work. Very near the drill and connected to it by two short lengths of hose is a small air compressor, or, more properly, a pulsator, mounted upon a little truck. This constitutes the entire apparatus of a single drill. Each drill is accompanied by its individual pulsator in the same way, and each pulsator is connected to the line of wire from the power-house.

The usual drill shell is employed and this may be mounted upon tripod, bar or column, according to the work. The drill cylinder fitted to slide in the shell is moved forward or backward by the feed screw. The cylinder is as simple as can be imagined; a straight bore with, at each end, a large opening and a boss to which to attach the hose. The piston also is plain, much shortened in the body, with a large piston rod, which has a long bearing in a sleeve elongation of the cylinder.

Upon the truck is mounted an electric motor, geared to a horizontal shaft with cranks on each end, which drive two single-acting trunk pistons, making alternate strokes in vertical air cylinders. One of these air cylinders is connected by the hose to one end of the drill cylinder and the other end of the cylinder is connected by the other hose to the other air cylinder. The air, therefore, in either air cylinder, in its hose and in the end of the drill cylinder to which it is connected, remains there constantly, playing back and forth through the hose according to the movements of the parts, being never discharged and only replenished from time to time to make up for leakage. The propriety of calling the apparatus a pulsator instead of a compressor is evident.

The essential details of the cycle of operation will be easily understood. We may assume, to begin with, that the entire system is filled with air at a pressure of 30 or 35 pounds. This pressure, being alike upon both sides of the drill piston, there will be no tendency for it to move in either direction. If, now, the motor, instead of being at rest, is assumed to be in motion, one pulsator piston will be rising in its cylinder and the other piston will be descending in its cylinder; and, as a consequence, the pressure upon one side of the drill piston will be increased and the pressure upon the other side will be proportionately reduced, this difference of pressure causing the drill piston to move and make its stroke. Just before the drill piston reaches the end of its stroke, the movement of the pulsator pistons is reversed, preponderance of pressure is transferred to the other side of the piston, causing a stroke in the other direction, and so on continuously. The drill thus makes its double stroke, or at least receives its double impulse, for each revolution of the pulsator crank shaft.

This is a sketch of the general principle of operation; we may now consider some of the details. The drill cylinder, shown in Fig. 2, while generally similar to that of the air or steam operated drill, is in many respects quite different, and especially is it remarkable for its simplicity. The usual operating valve chest, the valve and the complicated means for operating it, the main air ports and the intricate little passages in and connected with the chest are all conspicuous by their absence, and nothing takes their place. The cylinder heads are both solid and both fastened securely in place. The split front head, the yielding fastenings for both heads, the buffers, the springs, the side rods, etc., of other drills are all banished. The cylinder is absolutely plain, with the boss at each end to which the hose is attached and the direct openings into the interior.

The piston also has been simplified. The rotation device is necessarily retained, but the enlargement at the end of the piston rod, which constituted the chuck and necessitated the split front head, is not. The piston rod throughout is much enlarged and a simple but effective self-tightening chuck is slipped on to the end of it.

The compressor or pulsator cylinders are as simple as the rest. There are no valves, either inlet or discharge, and there is no water jacketing nor the slightest need of any. The heating of the air upon the compression stroke is compensated for by the fall of temperature accompanying its re-expansion, so that the air does not get hot and does not heat any of the parts with which it comes in contact.

While this apparatus as a whole may appear complicated at first glance, it really is a great simplification, and the parts got rid of are those which have always been most troublesome and have entailed the most care and expense to maintain. The drill and the compressor or pulsator are each the simplest ever built.

There are some minor details of this apparatus with which it is not necessary to burden this paper and which would involve tedious explanation that all would not follow. In our description of the principle of operation of the drill we assumed a mean air pressure of about 30 pounds in the apparatus, and it may be asked how this pressure is secured and maintained. When the pulsator is in operation the air pressure in the cylinders both rises above and falls considerably below the mean, and at a certain point it is below that of the atmosphere, when, of course, a little valve provided will admit more or less air, this process continuing until sufficient air is supplied. In the beginning of operations the influx of air is rapid, so that no time is lost in getting sufficient pressure to begin with. The admission and also the apportioning of the relative vol-

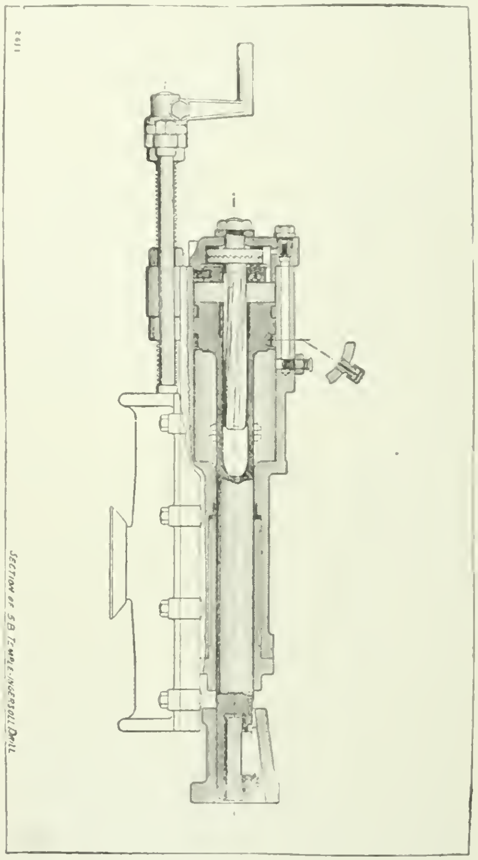


FIG. 2. SECTION OF ELECTRIC AIR DRILL.

umes of air to the two ends of the drill cylinder are easily adjusted by the operator.

With the Electric-Air drill there is no freezing up or choking of the exhaust, because there is no exhaust; the air also does not accumulate moisture and the temperature does not fall to the freezing point. The air does become and remains a constant vehicle for the conveyance and distribution of the lubricant, and with a certain amount of oil contributed to the system at regular intervals the problem would be how to prevent its reaching every working part rather than the reverse.

The length of hose employed seems to be limited to about 8 feet for each, and these may be attached to either side of the drill, but each always to its own end of the cylinder. This length of hose gives all necessary liberty for the location of the pulsator truck near the drill. The truck is of steel, with flanged wheels usually made for the standard 18-inch mine track, but may be made for any other gage. When in use there is no necessity for any care in leveling the truck, as the pulsator will work at any angle at which the truck can stand.

The motor may be either direct or alternating current, the latter being preferred because of the simple mechanical features. It is also smaller and lighter, a simpler and hardier machine and more nearly fool-proof. Four different speeds may be obtained with the direct current motor and two speeds with the alternating current, full speed for steady running and a considerably lower speed for starting a hole or working through bad ground, with immediate transition from the one speed to the other as required. The controller is on the top of the motor and the operator at the drill can start, speed or stop the motor by simply pulling a cord, this being the only connection. The electrical connection ends at the motor; both the hose and the cord insulate the drill and the operator is never exposed to the current.

The 5-C Electric-Air drill may be regarded as the full equivalent of the 3¼-inch standard air drill of any make; of its efficiency in comparison something will be said later. The power requirement for operating this drill is 18 to 20 amperes at 220 volts, or 9 to 10 amperes at 440 volts, the electrical equivalent of about 5 horse-power. The system being a closed circuit this is independent of altitude conditions, which make such a difference with the ordinary air drill, or, rather, with the work of the air compressor which supplies the ordinary air drill.

The 4-C Electric-Air drill, using a 3 horse-power motor, is a much lighter drill throughout and equivalent to a 2½-inch standard air drill. The table gives particulars of size, weight, etc., of both of these drills:

The dimensions and weights of the "Baby" or 3-C Electric-Air drill cannot as yet be made a permanent record. This drill takes the place and does the work of the "Baby" air drill.

The Electric-Air drill strikes a blow normally so much harder than that of the air drill of the same capacity, that in many cases it is found advisable to dress the steels blunter or thicker to avoid breakage. The practical force of the drill was not first worked out in computation, but has been demonstrated in extensive practice and protracted experiment. The explanation has come later, but is clear and sufficient.

The drill piston when running at full speed, making a stroke for each rotation of the pulsator crank shaft, will not strike either head. The hole by which the air enters the cylinder from the hose is not located at the extreme end of the cylinder, or close to the head, but a certain distance away from it, so that when the piston approaches the head a certain portion of air is enclosed and acts as a cushion which first checks the advance of the piston and then shoots it back. The piston thus starts upon its working stroke impelled by a certain amount of force which, we may say, has been saved over from the preceding stroke to be utilized for this. The piston after being thus started is driven forward by an air pressure which increases as it advances, the pulsator piston being in the attitude of chasing and gaining upon the drill piston for a considerable portion of the stroke, while in the case of the ordinary drill piston, driven by a constant flow of air which it runs away from, the pressure must constantly diminish as the piston speed is accelerated. In the same way by the action of the other pulsator piston the opposing pressure upon the advancing side of the drill piston is a diminishing pressure instead of the constant atmospheric resistance, and these combined cause a greater unbalanced difference of pressures upon the opposite sides of the drill, a more rapid acceleration of the piston movement and a consequent higher velocity and force at the moment of impact of the steel upon the rock.

Perhaps the most gratifying, and also surprising, revelation of all in connection with the Electric-Air drill is the now indisputable fact that it takes only one-third to one-fourth of the power, at the power-house, to drive it to do the same work. This is accounted for by the fact that the same air is used over and over and that all of its elastic force is availed of in both directions, instead of exhausting the charge for each stroke at full pressure. There are also no large clearance spaces to fill anew at each stroke, as these spaces are never emptied.

DIMENSIONS, WEIGHTS, ETC., OF TEMPLE-INGERSOL ELECTRIC-AIR DRILLS.

	5-C	*4-C*
Diameter of drill cylinder	$5\frac{5}{8}$ inches	$4\frac{3}{4}$ inches
Length of stroke	8 "	7 "
Length of drill, end of crank to end of piston	45 "	42 "
Depth of hole drilled without change of bit	24 "	20 "
Depth of vertical holes machine will drill easily	16 feet	8 feet
Diameter of holes drilled	$1\frac{3}{4}$ to $2\frac{3}{4}$ inches	1 to $1\frac{1}{2}$ inches
Strokes per minute	425	460
Horse-power (at motor)	5	3
WEIGHTS		
Pulsator complete, with *direct*-current motor mounted on truck	883 pounds	585 pounds
Pulsator alone	271 "	160 "
Truck	102 "	100 "
Motor	400 "	275 "
Motor without armature	330 "	216 "
Armature alone	82 "	59 "
Controller, switch and rheostat	72 "	50 "
Entire equipment ready for shipment, including drill, Pulsator, direct-current motor, fittings, wrenches and extra parts, but not mountings, steels or blacksmith tools	1680 "	902 "
Pulsator complete with 30 or 60 cycle *alternating* current motor mounted on truck	630 pounds	360 pounds
Pulsator alone	271 "	160 "
Truck	102 "	100 "
Motor	202 "	137 "
Motor alone	46 "	34 "
Controller switch with base	45 "	45 "
Truck cross bars for motor	15 "	15 "
Entire equipment ready for shipment, including drill, Pulsator, 30 or 60 cycle alternating current motor, fittings, wrenches and extra parts, but not mountings, steels or blacksmith tools	1080 "	680 "
Tripod with weights	540 "	430 "

NOTE: Weight of column and shaft-bar mountings will vary with their length and diameter.

A curious result of the mode of driving the piston of the Electric-Air drill, and another valuable feature of it when in operation, is found in the trick the drill has of yanking itself free when the bit sticks in the hole and going on with its work again. When the bit of the ordinary air or steam-driven drill sticks in the hole that is the end of it as far as the drill is concerned, and it is for the drill runner to free it as best he may. He runs the feed up and down, hammers the steel and coaxes things in various ways until the drill gets steadily running again. With the Electric-Air drill when the bit sticks the motor and the pulsator pistons do not stop, but keep running the same as before. This means that if the drill piston is making, say, 400 strokes a minute it will, when it sticks, receive per minute 400 alternate thrusts and pulls with full force. Nothing could well be imagined more effective for freeing the bit, and often when it sticks and before the runner can get ready to do anything about it the drill is running right along again as if nothing had happened.

The coming of the Electric-Air drill suggests many possibilities and ominously means much to the established interests. It necessarily suggests a revolution in methods and sometimes perhaps a superseding of the old plants throughout. In the working of the new drill the old central air compressor plants are absolutely worthless, but it is not easy to imagine any general abandonment of them. After all, the result may probably be that the new drill will not, to any great extent, drive out the old, but will make a new field of employment for itself, and in that way lead, as usual, to a considerable enlargement of the already extensive business which is behind it.

As has been shown, the Electric-Air drill is as far as can be from being an electric drill, but it makes the ordinary electric current nearly everywhere obtainable immediately available for driving it.

In the planning of installations which are new throughout, the Electric-Air drill is to be most seriously considered. The question of the relative final cost of operating this drill, or any other, is, after all, the decisive one, due recognition being given to the peculiarities of each, favorable or otherwise, which are not computable but which still have their weight in determining our selections, "other things being equal."

When the Electric-Air drill is operated without its own generating plant, the current being taken from a large power company, some very low figures are already on record. At Idaho Springs, Colo., a mine shaft was put down 67 feet in twenty-four shifts and the total power cost was $24 for the entire work.

In making rock excavations for building purposes in New York City and elsewhere, steam drills, having a temporary boiler installation, are frequently used. The Electric-Air drill not only avoids the expense of the boiler equipment but will do the work at a much lower cost, the current being supplied by one of the big electric power companies.

MACKELLARITE AND STRANLEIGHITE ENERGY

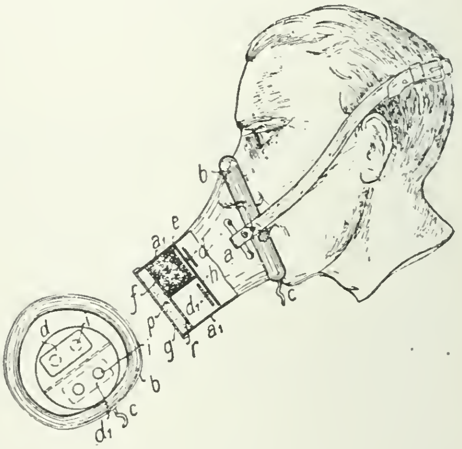
"Mackellar, there is one characteristic which I do not like about you. Perhaps, it is oversensitiveness on my part, but it sometimes seems to me that you think I am lacking in energy. I may find it difficult to put your mind right on this subject. Let me give you an illustration, chosen from your own interesting profession of mining-engineering. I am credibly informed that if a hole is drilled in a piece of hard rock, and a portion of dynamite inserted therein, the explosion which follows generally rends the rock in twain."

He paused, and there was no reply. Unabashed, his lordship proceeded:

"That is energy, if you like. Shall we name it a Mackellarite form of energy? Now I shall tell you of a thing I have seen done on one of my own estates. A number of holes were bored in a large boulder, and instead of dynamite, we drove in a number of wooden pins, and over these pins we poured placidly clear, cold water. After a time the rock gently parted. There was no dust, no smoke, no flame and fury and nerve-shattering detonation, yet the swelling pins had done exactly the same work that your stick of dynamite would have performed. Now, that also was energy, of the Stranleighite variety. I suppose it would be difficult to make a stick of dynamite understand the stick of wood, and *vice versa.—Saturday Evening Post.*

DUST MASK FOR ROCK DRILLERS

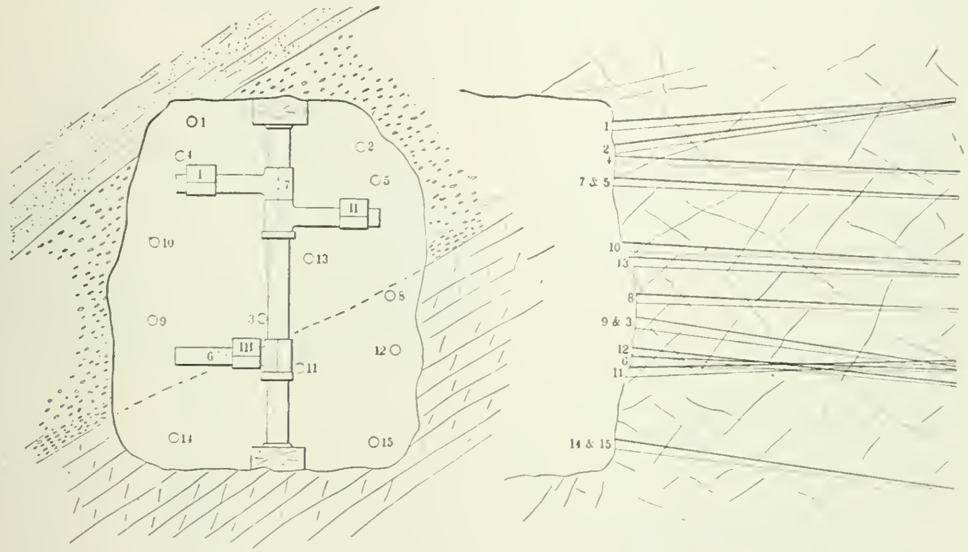
The mask illustrated in the drawing has been in use for some time at the Katharina shaft of the Herkules Colliery, near Essen, for protecting the rock drillers from the dust produced by the powder drills. It consists of a conical sheet metal casing, *a,* extended at one side into a cylindrical attachment, a_1, and fitted round the other end with a tubular rubber pad, *b,* which can be inflated through a small rubber pipe, *c,* in order to make a dust-proof joint all round against the face of the wearer. The thin iron partition, *h,* in the cylindrical attachment, a_1, is provided with four apertures, *i,* which are covered by two rubber flaps, *d* and d_1, serving as valves. The upper flap, *d,* is mounted on the side next the wearer's face; the bottom one on the lower side of the partition, *h,* so that the two open and close alternately during inhalation and expiration. The upper part of the cylindrical attachment, traversed by the incoming air, is occupied by a sponge, *f,* mounted between a front and back plate of wire gauze, *e* and *r,* the latter being covered with a loose stratum of cotton waste, *p,* to absorb the dust. The



front of the mask is covered by a third plate of gauze, *g*. For use the mask is fitted over the mouth and nose, and fastened over the head by straps, as shown in the figure. It appears to act satisfactorily, and the men like to wear it.

MULTIPLE ARRANGEMENT OF DRILLS ON THE RAND*

In the Cinderella Deep Mine in the Transvaal the system of using three machines rigged on one bar, in pushing forward an ordinary 7x5 foot drift, was introduced by Manager Girdler Browne. The use of this method established a record, on the Rand, for rapid driving, and this was performed at a depth of over 4,000 feet. I believe some American tunnels have been advanced at a greater rate, and I should be glad to hear from any correspondent on the subject. The advance was 225 feet in a month of thirty-one working days. Three men with five or six natives and sometimes a white assistant, worked in eight-hour shifts. Compressed air was freely used for blowing out the smoke, and the rock was wetted after a blast. As soon as the rock was sufficiently shoveled back from the face the miners returned, set up the drills and started drilling while the rest of the rock was being removed. The rock had to be trammed 500 to 800 feet. The best previous drifting record was in the Roodepart district, in soft ground requiring only nine holes per round. The distance driven was 220 feet in one month.



MULTIPLE MOUNTING OF DRILLS ON THE RAND.

On the Cinderella Deep the quartzites, forming the hanging wall of the banket reef, are very hard. The reef itself is of moderate hardness and the dark quartzites or quartzose slates, under the reef, are fairly soft. The illustration shows a normal face bored out with fifteen holes. When the drive gets more into the hanging wall more holes may be required. Four or five holes may be necessary on either side and perhaps other easers. The bar, which is usually a "double-jack" bar, is rigged as securely as possible about 4 feet from the face. One arm is rigged, as shown, to put in a flat hole in the hanging wall; another is fixed directly below this to bore the roof-hole on the other side of the drive. Safety clamps are put on under these two arms and also under the bottom arms. The third arm is rigged lower down to bore the top hole of a three-hole cut. This is generally put in to take advantage of the contact between reef and footwall. The two dry holes and the cut hole are first slated and then the holes of the face are bored in the rotation shown by the numbers on the drawing. The top machines drill the shoulder holes, No. 4 and No. 5, without altering the arms.

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*Edgar Nichols, Mining Engineer, Brakpan, Transvaal, in Engineering and Mining Journal.

No. 1 machine drills holes 1, 4, 7, 10; No. 2 machine drills holes 2, 5, 8, 11, 13; No. 3 machine drills holes 3, 6, 9, 12, 14, 15.

Though No. 1 machine has only four holes to drill, the flat hole in the hanging wall takes so long that it is not finished much before the others; the No. 2 machine has all water holes to bore and should be rigged under the arm drilling the lifter holes 14 and 15 before No. 2 machine comes down to drill hole No. 2. No. 2 machine has hole 13 to drill after No. 1 has drilled hole 10. If possible No. 1 machine is not given more to do after it has bored hole 10, as it is almost impossible to work with all the arms low down on the bar. Very often when the footwall ground is soft No. 3 finishes first and it can then be used to collar holes for the other machines. In the same way Nos. 1 and 2 machines can cross-collar difficult holes for each other. About four 1¼-inch sticks of blasting gelatin are placed in each cut hole and from five to six in the other holes. The cut is blasted first, then the easers, then the shoulder and knee holes, then the back holes, and lastly the lifters. No. 8 hole is run in under the contact of reef and footwall to prevent any lump being left on the side of the drift. The drift is run at a grade of one in 150 to 200 and has a single track with sidings every few hundred feet. It is considered quicker to run the drive 5x7 feet, as shown, and to use a single track only, than to take the drive out full width for a double track and to rig four machines. For a long drive the drift is squared off by hand labor to allow of a ventilating pipe being laid along the track. Before the regular work of stoping is started the drive is widened out and double tracks are put in.

Several of the Deep mines are installing monorails for tramming, the Langlaagte Deep mine being the pioneer in this work. It is hoped that, by using rails suspended 4 or 5 feet from the floor on iron brackets, friction will be much reduced and that the installation of some system of mechanical haulage will be rendered practicable. The air pressure employed in the Cinderella Deep was about 80 pounds per square inch. Machines with 3¼-inch cylinders were employed; combination piston and slide-valve; star-section welded steel bits, up to 5-foot lengths and longer lengths of chisels were employed. The diameter of starter bits was from 2¾ inches to 3 inches and the difference in gauge about 0.25 inch.

HOT AIR FOR DRIVING FANS

E. H. Dennison, in *Consular Reports*, says that a German firm has recently introduced at Bombay a portable fan driven by a hot-air engine which is destined to have a large sale throughout India. He says that owing to the intense heat which prevails in that country during most of the year fans of some kind are a necessity to the comfort of Europeans, and their offices, shops, and residences are all equipped with the old-fashioned swinging screens known as "punkahs," which consist of a piece of cloth or matting stretched over a rectangular frame hung from the ceiling and kept in motion by a servant at the end of a cord. Wherever electricity is introduced these are generally superseded by electric ceiling fans.

The natural field for the hot-air engine fan would be in localities where there is no electric power, but it has been found that it can compete with the electric fan in the latter's own field, owing to the extreme cheapness of the cost of its running, which is about one-fifth of that of the electric fan.

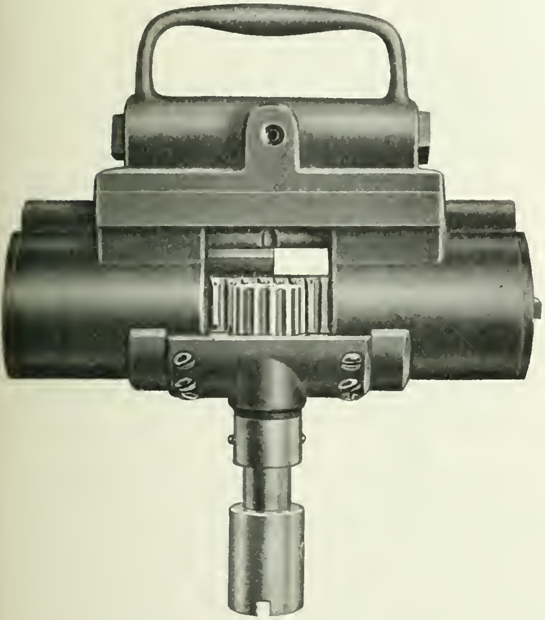
The fan is propelled by a hot-air engine, the heat being generated by a kerosene lamp which holds about 1 quart of oil, sufficient to keep the fan running for over twenty-four hours. To the lamp is attached a small glass chimney which fits into a larger metal chimney connected with the engine. Upon the top of the engine is hung the fan, similar in shape and size to the ordinary electric fan, whose speed is governed by the size of the flame; that is, to reduce the speed the flame is turned down, and to increase it the flame is turned up. The whole outfit weighs about 30 pounds, and sets upon a small stand, raising the level of the fan proper to that of an ordinary desk.

If American manufacturers can produce a similar article, with perhaps a few improvements and at a smaller cost, an immense field will be found for its sale, for this is not necessarily limited to India, but would include every hot country in which white people are compelled to live.

These fans at present sell for $62 each, which makes them rather too expensive to be used by any but the well to do. However, the manufacturer expects to soon be able to materially reduce this price with the expected larger output.

A PNEUMATIC OSCILLATING VALVE GRINDER

The tool here shown will at once appeal to the man of the shop. So far as known, it is the only one of its class, and in its advent it at once supersedes hand labor for an important operation. The grinding and regrinding of valves for pumps, air compressors, gas and gasoline engines, and angle, check and other valves of metal, is a frequent and familiar job, and up to the present time it has been done almost entirely by hand, because it will not permit continuous rotation. The valve must be turned back and forth or the seats will be scratched and scored instead of being smoothed by the grinding.

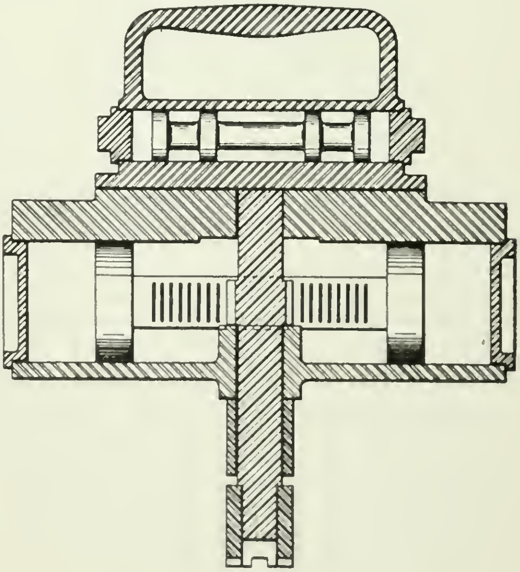


This tool does the trick continuously and automatically and requires no explanation. A rack with a single-acting piston at each end of it works back and forth, and meshing into a pinion on the spindle produces the intermittent and continuously reversing rotation. A single spool valve comprises all the other mechanism. The size of the grinder is 9 x 10½ inches and it weighs 14½ pounds. Air connection is made through ¼-inch hose nipples. Chucks or drivers can be fitted according to the style of valve to be ground.

When desired a rigging may be used to support the grinder, consisting of a bar attached to the body of the driver near the handle and pivoted at one end to a stationary support. Then by raising or lowering the other end, the grinder may be properly applied to the work and the pressure regulated as desired. The grinder is made by the Cleveland Pneumatic Tool Company.

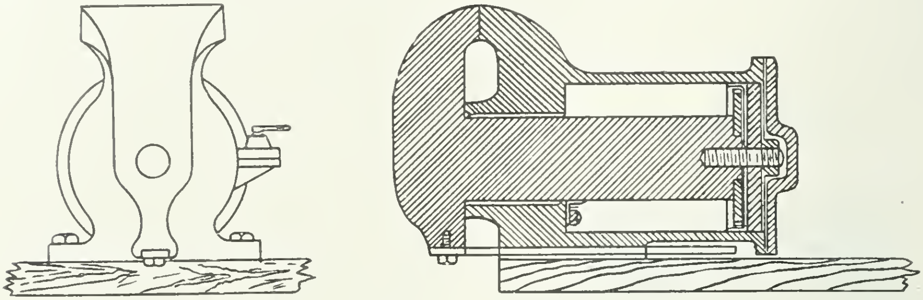
An interesting use to which gypsum is put, especially in England, is the *burtonization* of beer. The reputed excellence of certain British beers, notably those of Burton and Newark, is attributed to the presence of calcium sulphate in the natural water used in their preparation. It has been calculated that 350,000 pounds of gypsum are annually imbibed in potations of Burton beer, and since gypsum is soluble to a certain extent, attempts have been made with varied success to add similar artificial salts to water not derived from gypsum-bearing beds, and large quantities of gypsum are purchased by brewers in England for this purpose. This addition, although advantageous, does not produce so perfect a combination of salts as that existing in the natural waters of Burton-upon-Trent.

Each horse-power used for manufacturing in Pennsylvania produces annually an average of approximately $1,000 worth of goods, according to a bulletin issued by the McCall Ferry Power Company.

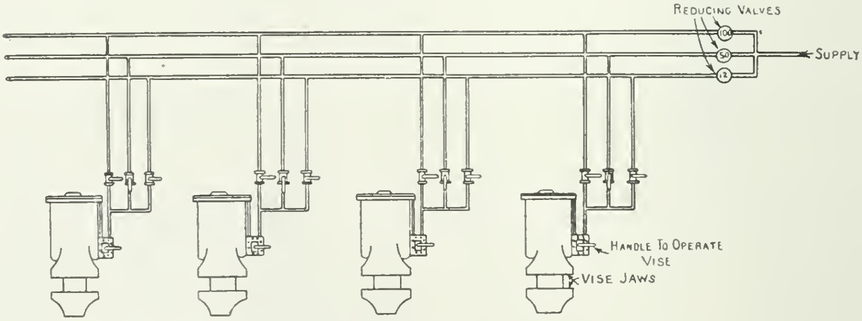


AIR-OPERATED VISE

The cuts on this page, taken from *Railway and Locomotive Engineering,* show a compressed-air-actuated vise, invented by Mr. J. E. Osmer, Master Mechanic of the Northwestern Elevated Railroad of Chicago. The action of the vise is simple and scarcely requires explanation. In the size of vise most used the working cylinder is 7 inches in diameter and the rod 4 inches, and with 100 pounds of air pressure the grip is 2,590 pounds. A guide at the bottom prevents the rod and jaw from turning. To open the vise no additional air is required. There is a run-around passage at the side of the vise and a little valve opens communication with the back of the piston, and when the air is thus admitted to the larger piston area the difference forces the jaw out as required. Not more than ⅛-inch piping is required for the largest size, and the air consumption is inappreciable in a shop where a constant air supply is maintained. By piping up as shown in Figure 2, with reducing valves giving different pressures, either pressure may be used at will according to the grip required. For three pipes and three different pressures, as shown, of course only two reducing valves would be required.



AIR OPERATED VISE.



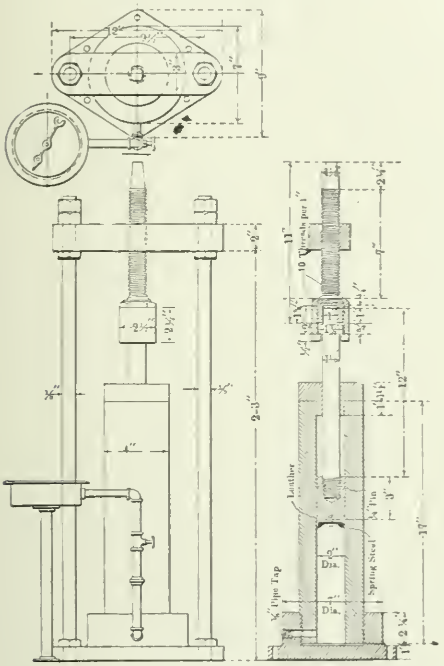
PIPING FOR AIR VISE.

A MECHANIC PRIEST

Near the northern coast of France, on a route much frequented by motorists, lies the village of Graincourt. Here a beautiful little church is set high among the trees. Close by is the home of the priest, and around it a strange litter of bicycles, motor-cycles, automobiles, oil-cans, and tools, while the open doors reveal on one side a kind of garage, on the other a repair shop. From this building, as the tourist approaches, comes a tall figure, with the body of an athlete and the head of a missionary, and muscular arms bared to the elbows. This is the curé of Graincourt, who is now village mechanic as well. His father was a smith, and he grew up with a passion for tools. When the bicycle came in he became an amateur specialist. Then came the motor-car, which won the heart of the curé. He loves it, and thinks he understands it. He has even built a car and a motor-cycle for himself. And so the fame of the mechanical curé of Graincourt has gone abroad throughout all the country, and at last he has decided, without any scruple, to make a business of what had formerly been a pastime.

A TESTER FOR PNEUMATIC DRILLS

The cut, which we reproduce from the *American Engineer and Railroad Journal,* shows the details of a device for testing the torque of rotative pneumatic drills in use in the tool room of the McKees Rocks shops of the Pittsburg and Lake Erie Railroad. The top of the main screw of the apparatus is square and the spindle of the drill to be tested is applied to it by means of a suitable chuck. As the screw descends the piston in the cylinder below produces a pressure upon the oil and when the drill is stalled the pressure is noted on the gauge at the side. It is said that different makes of drills guaranteed to be of the same power have shown a range of from 1,800 to 5,500 pounds. When a new drill is received it is tested and a record is made of its capacity. When the drill requires repairs or any complaint is made it is tested to determine whether its capacity is still normal, and after repairing it is tested before it is handed out. The records made are, after all, only comparative, but they are sufficient for practical service.



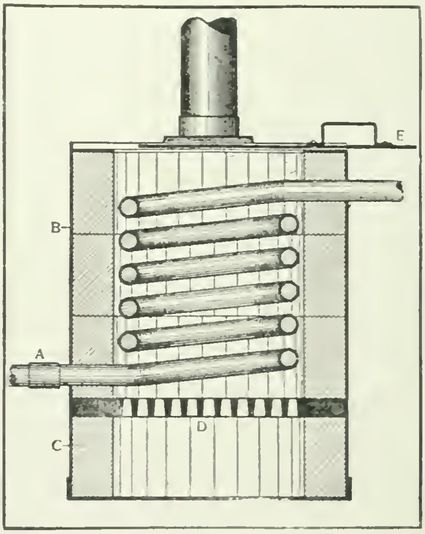
TESTER FOR PNEUMATIC DRILLS.

A CHEAP REHEATER

The little engine, driven by compressed air, of which I have charge, is a long distance from the compressor (3,000 feet) and thus the heat produced by compression all escapes before the air reaches the engine.

When first started, the engine would run all right, but after it had been running a few minutes the valve would work stiff and the link would begin to quiver. Then the piston would groan, and after running irregularly for a little while the engine would stop altogether and all the pressure we had wouldn't move her an inch until the cylinder was thawed out

In order to overcome this difficulty and at the same time to expand the compressed air, I built the reheater here shown, which successfully prevents the engine freezing up and materially reduces the consumption of air.



A CHEAP AIR REHEATER.

A piece of 1-inch pipe was coiled as shown at A, and enclosed in a sheet iron casing, B, having lap joints riveted together. This was lined with fire brick as shown at C, and provided with a circular grate, D. The fuel is put in from the top, which is covered by a sliding lid, E, of sheet iron. Another sliding door, not shown in the sketch, is placed at the bottom to allow the removal of ashes and to regulate the draft.

This reheater has been so successful that we now run it all the time; even during the warmest weather when there is little danger of freezing, the object being to reduce the amount of air used. The engine develops 12 horse power with 85 pounds air pressure.—*A. E. Scheetz, Trevorton, Pa.—Popular Mechanics.*

COMPRESSED AIR AND THE KINETIC THEORY OF GASES*

To the ordinary consumer of compressed air it serves simply the purpose of an energy reservoir and for power transmission. Its utilization in this field is so efficient and it is so easily obtainable that it is doubtful if it will ever be replaced by any other material. In reality, however, the general viewpoint of compressed air as an energy reservoir is fallacious—compressed air contains no more energy than ordinary air. Compressed air is simply air which has been compressed to a higher pressure and the laws which govern it are simply those which hold throughout in the kinetic theory of gases. According to this theory, a gas is made up of individual molecules flying around through space like small projectiles, colliding and re-colliding with each other and with the walls of containing vessels. The summation of this series of blows on a surface constitutes what is known as pressure. The real meaning of temperature is absolutely unknown, but it is known that absolute temperature to-day is directly proportional to the mean kinetic energy of these small projectiles or molecules.

To show that the first statement in regard to compressed air as an energy reservoir is true, all we need to consider is the fact that the temperature, if not identical with, is at least proportional to, the energy of the molecule. When a gas is compressed the molecules are given an increased amount of kinetic energy. This means that they are raised in temperature by compression. If the gas now under pressure is allowed to cool off to normal temperatures it thereby loses the energy which has been put into it and which has become apparent as an increase in temperature. Each molecule possesses precisely the same kinetic energy as before compression, and in a gas, unless extreme compression is accomplished, the molecules still remain at a distance sufficiently apart to have no influence on each other. Hence the total kinetic energy in the gas under compression is identical with the total kinetic energy in the gas before compression. Of course, the energy has been concentrated in amount per cubic foot, but if this gas were allowed to expand in a cylinder without access to the outside air, or, rather, without thermal connection with surrounding bodies, little or no work could be obtained from it.

COMPRESSED AIR MERELY TRANSFORMS ENERGY.

In reality, a gas under pressure, when it starts to expand, loses some of its energy to the piston. It then possesses a smaller amount of mean kinetic energy per molecule, and is therefore at a lower temperature. It is immediately raised by the surrounding atmosphere, or containing vessel, to normal temperature, and can then continue doing work at this higher pressure, and the process continues until the pressures on both sides of the piston become equal. From this it is evident that compressed air is not a reservoir of energy in any form. Compressed air expanded freely into a vacuum does absolutely no work and does not cool off or lose energy.

This becomes evident when the compression on a pressure-volume diagram is considered. Every engineer knows that the curve which represents adiabatic compression is steeper than the curve representing isothermal compression. Of course, the object in compression is to get the curve as near isothermal as possible in order to diminish the amount of work necessary to produce the compression. Hence, we have three-stage compressors in which the gas is compressed adiabatically, then cooled off to the temperature that it would have had if compressed isothermally, and the process repeated twice, giving three stages. This results in an increased efficiency of production, but since the processes are identical in action, only one—that of the single-stage compressor—need be considered. In this the compression is generally adiabatic, then the curve drops vertically to the isothermal point as the gas cools off and the pressure diminishes on this account without change in volume. At this point in the diagram, however, the gas has reached another adiabatic curve passing through this point so that the total change in the gas is in reality simply a change in pressure, volume and entropy, whatever the latter may mean.

KINETIC THEORY CLEARS UP COMPLEX POINTS.

There is no doubt that a capable treatment of the subject of compressed air from the standpoint of the kinetic theory of gases elucidates many complex points and renders clear much that is otherwise obscure. This conception of the energy in compressed air explains clearly the inability to utilize it in free expansion. In the transference of energy from place to place, through long pipes, this is carried on by a series of bombardments from molecule to molecule and explains the time taken in transmission and the loss of energy, or the diminution in pressure, which results when the transmission is long. It enables the engineer to understand clearly what occurs in compression and what is meant by the different kinds of compression. Thus, adiabatic compression means compression in which heat, as such, does not pass to or from the air or gas in the containing vessel. Every time molecules are hit by the piston they are forced to rebound and given an increased energy. This energy is not lost in adiabatic expansion to the walls of the containing vessels. but is present when the molecules collide with the piston a second time. It explains by this reasoning the manner in which the pressure rises abnormally over that in isothermal compression.

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*Abstract of Paper by J. H. Hart in October Power.

In this latter the molecules rebound from the piston with an access of energy, but this is lost by transmission to the walls of the containing vessel before they collide again; hence the pressure does not rise abnormally over what it should theoretically be. In this respect the pressure depends simply on the force with which each molecule strikes, the number of times it strikes a second, and the number of molecules which hit per square inch of surface.

When a gas is compressed more molecules are contained in a given space, hence the bombardment increases both on account of increased number of molecules striking and on account of increase in number of times of striking per second. This explanation completely satisfies and explains the behavior of a gas in its relation to pressure and volume and also explains deviation from this relation, known as Boyle's law, and does it accurately and efficiently, so that theory is completely in accord with practice. In general, the kinetic theory of gases is the only thing that completely explains the behavior of gas under all conditions and, further, it not only does this but it has foretold many phenomena previously unknown and these have been verified by experiment.

There is no doubt that a study of the kinetic theory of gases completely elucidates many of the obscure points (and in fact all of them) in the conception of the compression of gases, if it is investigated sufficiently. Of course this is work primarily for physicists, but engineers are daily becoming more and more interested in physical science and it is absolutely necessary to-day that a compressed air engineer, or manufacturer, or even the consumer, should know enough of this development to understand the phenomena which are going on inside of the compressor. By this means reheating, and the reason for the increased efficiency obtained thereby, become simple and clear. The presence of moisture in the air and its effect on the efficiency also are easily understood.

VALVE ABUSES AND TROUBLES CONSEQUENT

A writer in the *Valve World* says that at least 90 per cent of the trouble with valves delivering water or steam—to which compressed air might of course be added—arises from the improper use of cement, and from a failure to remove the particles of cement, scale, chips, dirt, etc., which get into the pipe while it is lying around a building and lodge on the valve seat after steam or water is turned on. Cement should be applied on the male part only, for if placed on the female part it is likely to go through the pipe and land on the valve seat. Besides this, in nearly all cases more cement is used than is necessary.

Frequently, when a valve leaks, which is usually due to the presence of dirt in it, some one tries to tighten it by using a lever on the wheel. This nearly always injures the valve. It is much better to take the valve apart and clean the seat. Similarly, when a stuffing box leaks, attempts are often made to stop the leak by straining the stuffing box with a large wrench, when the real trouble is that the packing has become worn and needs renewing.

One of the common abuses is the use of a wrench on the opposite end of the valve from that which is being screwed on the pipe. This is particularly bad with light valves, as it is almost certain to spring them and cause them to leak. Again, with light valves, when placing them in a vise to remove the center piece, the valve should always be clamped lengthwise. In removing the center piece care should be taken to have the disk some distance from the seat; otherwise it will be forced down upon the seat and some part will become strained. Another trouble likely to occur in a line containing light valves results from failure to make proper allowance for expansion. The pipes and fittings are much more solid and rigid than the lighter brass valves, and the expansion strains will mainly affect the latter, unless proper allowance is made.

LUBRICATION OF AIR COMPRESSOR CYLINDERS

The occasional occurrence of fire in air compressor cylinders is due to oil, which is the only substance present that can burn, and the cause of this difficulty cannot be laid to the oil alone, although it is well known that an inferior oil can readily cause explosions.

That certain structural features of a given machine may facilitate or retard combustion of the oil will appear from what follows, and the fact of an air compressor drawing the air from whatever location it may be in, naturally necessitates the presence in the air cylinder of whatever foreign substance there may be in the atmosphere, as, for instance, in acid or alkali works, coal mines, copper mines, or other places of a similar character, where air is being drawn into the air passages of the machine. This combines with the excessive amount of residuum, or carbon left behind and through oxidation forms a substance for fire to feed on, the fire resulting from causes herein set forth.

The greatest amount of oxidation takes place at the point where the air passes from the cylinder into the discharge pipes, and through continued deposition decreases the size of the mouth of the discharge pipe, and more air is compressed in the cylinder than can pass through the discharge pipe, resulting in the recompressing of the air and an increased amount of friction, also an abnormal degree of heat in the air cylinder.

Oil should be of such quality as to cause the least oxidation possible, and the flash point should be as high as good lubricating qualities will permit. The flash point of oil is that degree of heat at which some constituent part of the oil passes off as vapor, which, being inflammable, will ignite if brought into contact with fire.

The mere raising of the temperature of an oil to its flash point will not produce ignition. Another cause must be presented to produce ignition of the vapor. Indeed, such a cause may operate before the flash point is reached, as in the case of sawdust saturated with linseed oil. Such a case is, according to my experience, oxidation of the oil. Combustion, so far as I have to consider it, is in this case, the rapid union of a substance with oxygen in the presence of a flame. There can be, of course, repeated oxidation without flame, but if the action be sufficiently repeated, heat enough will be generated to set the substance on fire, and if a considerable quantity of inflammable vapor be present, an explosion is likely to follow.

The engineer can prevent a crankpin or a crosshead pin or any other accessible moving part of the compressor from getting hot, but when it comes to keeping the heat out of the air cylinders or discharge valves the only way he can do it is by using high flash point oil in connection with a good water jacket around the cylinder. The engineer does not always get the right kind of oil he ought to have, for most of the companies buy oil as cheap as they can get it. It is true it is cheap in the beginning, but it is always the dearest at the end of the month or year.

Kerosene should never be used in an air cylinder, but, instead, fill the oil cup with soap suds made preferably of soft soap, one part soap to 15 parts water, and feed this into the air cylinder. Let the compressor work with soap suds instead of oil for a few hours, or say a day each week. Feed the solution liberally and then open the receiver blowoff and drain off the accumulation of oil and water.

This cleaning process should be repeated as often as necessary, the exact intervals depending on the service of the compressor. If running at full capacity for 24 hours a day, about once every week or two will be sufficient. If on a light load and running for eight or ten hours per day, once every month or two will do very well. The soap suds can do no harm, but care should be taken to feed with oil a half hour before shutting down so that the parts may not be subject to rust, which is the only danger from the use of soap suds.

Ignition in compressed air discharge pipe and passages is not uncommon, and at times this ignition is in the nature of an explosion. Two air receivers were blown up during the construction of the New York aqueduct and in one case the engine room was destroyed by fire resulting from this explosion. I witnessed an air receiver explosion recently when four men were badly injured and the air receiver was blown to pieces and thrown from the foundations. The cause of this explosion was the using of oil having a very low flash point. Ignition took place near the air compressor, the pipes becoming red hot at the joints.

This ignition has been known to extend into the air receiver, and in one instance the flames were carried down into the mines by the compressed air. In all these cases a large volume of compressed air was used, and it is plain that the explosion or ignition was due to an increase of temperature above the flash point of the oil. Steam cylinder or engine oil which is thick and gummy should never be used in an air compressor.

I know, however, of an instance where ignition took place with oil which had a flash point of 575 degrees F. and the ignition point 625 degrees F. The conditions were similar to those mentioned; that is, the air was compressed to about 60 pounds per square inch, gage pressure. If the temperature of the air before admission to the compressor is 60 degrees F., and it is compressed to 58.8 pounds gage pressure, the final temperature where no cooling is used during compression, will be 309.4 degrees. If air admitted at 60 degrees F., is compressed without cooling to 73.5 pounds gage pressure, the final temperature will be 414.5 degrees F. and the total increase of temperature 354.5 degrees.

Under such circumstances the question arises, how is it possible when using oil with an ignition point of over 600 degrees to get an ignition, especially as water jackets and other methods of cooling are used which should reduce the final temperature? The figures are also based on dry air, which increases in temperature to a greater degree than moist air, and it is known that air which is used in compressors is never very dry. The theoretical figures show that in order to get ignition with the oil mentioned, the gage pressure should be about 200 pounds per square inch. Where a cooling takes place it is plain there must be an increase of temperature, or ignition would not take place. This increase of temperature may result either from an increase of pressure which is not recorded on the gage, or there may be an increase of temperature without a corresponding increase of pressure. Take the first instance, and it is not difficult to understand that an air compressor might deposit carbon from the oil in the discharge passages or discharge pipes, which I found out to be the case, which in the course of time will accumulate and obstruct the passage so that they do not freely pass the volume of air delivered by the compressor, hence a momentary increase of pressure exists on the cylinder heads or in the discharge pipes which lead from the air cylinder to the receiver. This momentary increase of pressure would surely carry with it an increase of temperature which might exceed the ignition point of the oil.

A badly designed compressor with insufficient discharge passages will produce this trouble. Too small a discharge pipe will also tend to produce explosions, but I know instances where ignition has occurred in a well designed system, hence we must look for other causes. A hot engine room from which air is drawn into the cylinder is a bad condition. I know of a plant where the incoming air was drawn from the neighborhood of the boiler room, the temperature being close to 150 degrees. When air is compressed to 73.5 pounds gage pressure it is 345.5 degrees. The temperature of the initial air should be added to this figure and then the final temperature might be 504.5 degrees.

Ignition has taken place when the temperature of the incoming air was normal, and when the discharge passages and pipes were free and of ample area, hence we must look for some other cause. The only possible explanation that I make is that the temperature of the incoming air is made excessive by the sticking of one or more of the discharge valves, thus letting some of the hot compressed air back into the cylinder to influence the temperature before compression. When a piston of an air compressor has forced a cylinder volume of air through its discharge valves, and when this piston has its direction of movement reversed, there will immediately be a tendency of the air just compressed and discharged to return to the cylinder. In this it is checked by the discharge valves, but through long and constant use these discharge valves become incrusted with carbon and are not free to move.

I overhauled a compressor not long ago and found the discharge valves so incrusted with carbon that the only way I could take them out was by driving them out with the handle of the hammer. These valves had not been cleaned for ten months, and this was a case where the engineer either did not know how to clean them or did not care to do it, hence there was a moment when one of these valves stuck and did not seat properly. In either case there will be some hot compressed air in the cylinder, when the piston starts on the return stroke of compression. It is not difficult to understand how a leaky discharge valve will let enough air back into the cylinder to increase the initial temperature to 200 or 300 degrees. If so, and we are compressing air at 73.5 pounds gage pressure, we have, say, 300 degrees temperature in the free air before compression, and as the increase is 354.5 degrees, this will require frequent cleaning of the discharge valves and passages.

Continuing the important subject of explosions in compressed air passages, even with the best form of discharge valves, trouble may arise because of the use of bad oil or of *too much good oil.* Engineers are apt to suppose that an air cylinder of a compressor requires oil just as much as the steam cylinder. This is a mistake.

To obtain best results use oil in the air cylinders running at 40 to 50 revolutions at a rate of 1 drop per minute, which is plenty. Over 50 revolutions, 2 drops in a minute and a half gives the best results. The air cylinder lubricators should be adjusted to feed regularly and the lubricator should be closed the minute the compressor is shut down.

Some engineers find out that the carbon deposit is easily cut away by kerosene oil and they throw kerosene oil into the inlet. Kerosene has a flashing point of 120 degrees F., and it is not difficult to understand what the cause of the explosion is under such circumstances.—*L. A. Christian, in Engineers' Review.*

An oiler looking like a turnbuckle and nearly as strong is used about the mines in the Rainy Lake district of Canada. It is made of a piece of ½-inch iron pipe, one end welded up solid and the other end closed down and a ½-inch nut welded in. The stopper which screws in has an eye by which the oiler may be hung up, or a string may be attached to it. The oiler, without the plug, is about 14 inches long and carries oil enough for one shift.

A NEW THAMES TUNNEL

When the Blackwall Tunnel under the Thames at London was opened ten years ago it was hailed as the greatest engineering work up to that time, but it is now surpassed by the Rotherhithe Tunnel under the same river. The main object in view was the linking up of two populous districts badly in need of direct communication, both the northern and the southern approaches being in close proximity to important main thoroughfares.

The Blackwall Tunnel is used by 1,250,000 foot passengers and 600,000 vehicles annually, which figures will be largely exceeded by the Rotherhithe Tunnel. The tunnel is circular, the lower portion forming a subway for water pipes, electric wires, etc. There will be room for a roadway 16 feet wide and footways 4 feet 8 inches on each side, and there will be a headway of 18 feet 6 inches.

There seems to huve been no novel or difficult engineering problems involved. The tunnel was driven by the now familiar shield system using compressed air, and the nature of the ground was such that there was no appreciable danger. Some thirty men were employed in the face of the shield, which was divided into sections 6 foot square. The progress has been as much as 12 feet per day, or 2 feet more than on the Blackwall Tunnel. Instead of the open strata which occur in the river bed at Blackwall there is a solid bed of clay. The tunnel has been driven under this bed of clay through what are known as the Woolwich and Reading beds. The tunnel is lined with cast-iron rings surrounded with lime grout. Some 20,000 tons of cement have been used and nearly 1,500,000 white glazed bricks.

The work has been done considerably within the contract time. The total time allowed, five and a half years, does not expire until two years from the present writing, but it is confidently announced that everything will be completed in one year. The Blackwall Tunnel occupied six years in construction. From London Bridge to Hammersmith there are fourteen bridges; below London Bridge there is one, the Tower Bridge. This is supplemented by the Blackwall Tunnel, the Greenwich Subway and the Woolwich Ferry. Even with the addition of the new Tunnel, East London will still make use of the ferry service run by the river steamboats between the piers below the bridge.

SUCTION REQUIRED FOR ENGINEERING PARTICULARS

A man will go into a pump manufactory and ask for a pump. A salesman will ask him: "What do you want to pump?" "Why, water, of course." "Is it hot or cold?" "Cold." "How much do you want an hour?" "I don't know." "Well, 10,000 gallons?" "Oh, not 1,000, it's just for my house." "Have you got a tank, and what is its size?" "Yes, I have a tank, and it is about so long, so deep, and so wide." "Well, that would hold about 2,000 gallons. Now our No. 4 pump will pump you 1,000 gallons per hour 60 feet high. Is your house as high as that?" "Oh, no; only about 30 feet." "You have a boiler, have you?" "Yes."

The man is sent his No. 4 pump, but he did not give the correct size of his tank and neglected to say his house was on a hill 600 feet away and 75 feet high. The pump does not answer and the man is mad.

Now abroad this would not occur. The man would be told: "You are not a professional man and therefore do not know what you want; and we do not wish to risk our reputation by guessing. Now you take our card and go and see Mr. M. or Mr. P., both good engineers, and they will see what you need and we shall be glad to fill the order for any pump they name."

You do not have to seek long for the cause of the condition existing in the United States, as it is the great desire here to make a sale that causes the trouble.—*W. D. Forbes, M. E. to Senior Class of Stevens Institute of Technology.*

THE WORLDS LARGEST IRON MINE

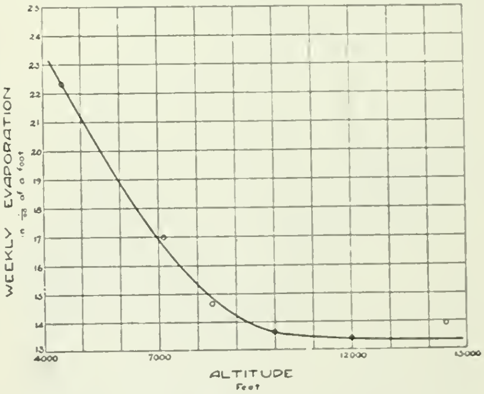
The United States Steel Corporation, through its subsidiary, the Oliver Iron Mining Company, is opening up what will be the largest mine of the kind in the world. With the aid of steam shovels and standard-gauge dump cars having a capacity of 7 to 9 tons, something like 20,000,000 cubic yards of dirt will be removed from the surface of the Canisteo iron ore deposit. This open pit, to be clover leaf in shape, covers 200 acres, and when the necessary development work has been done, will be from 160 to 200 feet deep. One of the principal features of this great enterprise will be the washing of the iron ores. Thousands of dollars have already been spent in the erection and operation of an experimental ore-washing plant.

INFLUENCE OF ALTITUDE ON EVAPORATION

During the summer of 1905, Mr. Frank Adams, of the Office of Experiment Stations, made a limited number of observations on the eastern slope of Mount Whitney, Cal., to determine the effect of altitude on the evaporation from a water surface. Temporary stations were established at the following points:

Station.	Elevation in feet.
Soldiers' Camp	4,515
Junction South Fork and Lone Pine Creek	7,125
Hunters' Camp	8,370
Lone Pine Lake	10,000
Mexican Camp	12,000
Summit Mount Whitney	14,502

The results of this investigation indicated a consistent and steady decrease in the evaporation of a 20-day period from the lower to the higher elevations. This is clearly shown by the accompanying diagram. The curve was made to pass underneath the small circle, which marks the weekly evaporation on the summit of Mount Whitney, for the reason that the exposed position increased the evaporation. The intermediate stations, although selected with care, did not possess altogether uniform conditions as regards the movement of air and the character of the surrounding materials. While these doubtless influenced the results to some extent it is safe to conclude that altitude was the controlling factor.—*Engineering News.*



STRENGTH OF AIR PRESSURE TANKS*

The first air pressure tank, of which we have record, to be used as a source of water supply for an automatic sprinkler system was installed about twenty-four years ago.

The idea seemed to have prevailed with steel inspectors that any plate that would not pass inspection for firebox or boiler steel was good enough for tank steel, and was as a rule, sent out as such. Fortunately, we have had only a few cases of failure of the air pressure tank, resulting seriously.

A tank installed in connection with a sprinkler system in a building in Chicago, Ill., subsequently exploded. The following is a brief description of the tank and the conditions that led up to the disaster: Steel tank, 5 feet 6 inches in diameter by 24 feet long. Total capacity, about 4,300 gallons. Shell 5-16 inch thick. Heads, 5-16 inch thick. Dish of head, 8¼ inches. Longitudinal seams, triple riveted, with alternate rivets omitted on center row. Girth seams, single riveted. Rivets, ⅝ inch in diameter. Holes, 11-16 inch diameter, placed 1⅞ inches apart and ⅝ inch from edge of plates. The tank was originally allowed 75 pounds presssure, which was subsequently reduced to 40 pounds, under which pressure, it is said, the explosion took place.

An examination revealed the following conditions: The South head was torn nearly off, the break occurring at the end girth seam and along near the edge of head plate, running in an irregular line for about five-sixths of the circumference of the tank. Rivets were sheared off at irregular intervals. Rupture at edges showed no flaws, but plates had been materially weakened by rust, being only 3-16 inch thick at bottom of tank, where the rupture apparently started, and in several other places. Exterior of tank had never been painted, and was badly rusted out. Interior surfaces were badly pitted to a depth of nearly 1-16 inch, also covered with hard globular incrustations.

An explosion or bursting of a pressure tank might be attributed to any one of the following causes:

1. Defective design, resulting in general weakness of shell.

2. Poor construction, including choice of defective or improper material; faulty workmanship; failure to follow instructions and drawings.

3. Decay of the structure with time or in consequence of lack of care in its preservation, etc.

4. Mismanagement, giving rise to excessive pressure; failure to make frequent inspections and tests and thus keep watch on those defects which grow dangerous with time.

Defective design in the recently constructed tanks would not be so common as other causes.

The use of thin, laminated, or blistered sheets, carelessness in the attachment of inlet and outlet pipes, bad riveting, inferior quality of rivets, etc., could be considered as defective construction. Only the most careful as well as conscientious builders can be relied upon to avoid all such faults and to turn out tanks strong and safe as the design and specifications may permit.

The progressing decay by corrosion will develop weakness, and undoubtedly may be considered the most likely of all causes directly responsible for rupture or explosion. A tank designed and constructed of the best possible proportions and of the best materials, having at the start a factor of safety of six, may be assumed to be safe, but, with the beginning of its life, decay also begins, and the original margin of safety is continually being lessened. The result is an early reduction of this margin to that represented by the difference between the working pressure and that fixed as a maximum by the underwriters' rules or the inspectors' tests. Should this difference be sufficient to insure against accident resulting from further depreciation, in the interval between the inspectors' tests, explosion will not occur; should the margin be not sufficient, there is a possibility of explosive rupture occurring when least expected.

Rupture commences at the point where the resistance offered by the material is less than the strain to which it is subjected. The principal cause, as stated in the foregoing, affecting the strength at any one or more points is corrosion and decay. Not until this can be at least held in check will the danger of rupture be entirely eliminated. The inspection of the external conditions of a tank is, as a rule, taken care of, but, in order to ascertain the true conditions as to whether a tank is safe or not, a thorough internal inspection is absolutely necessary.

The city of Chicago requires safety valves to be installed on pipe line from pumps to tank, where a tank is found defective from corrosion, or where any apparent weakness has developed, reducing the working pressure from 75 pounds to 60 pounds, and in many instances to 45 pounds. In decreasing the pressure, the efficiency of the apparatus is considerably reduced.

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*From a Paper by Iry J. Owen, M. E., in Insurance Engineering.

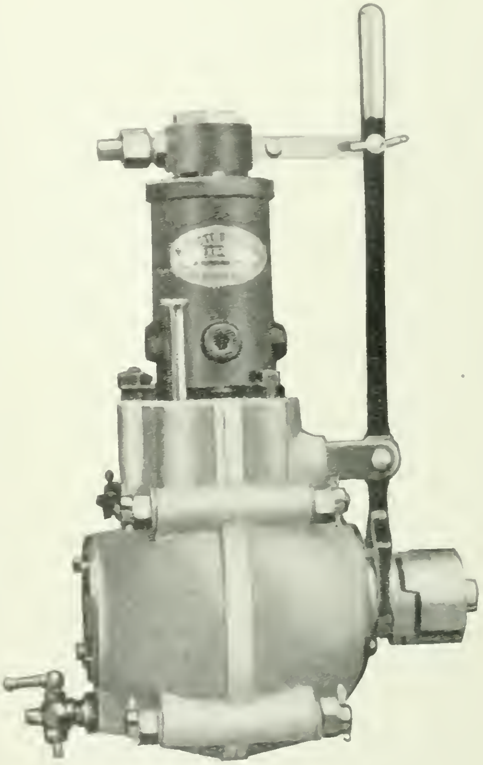
SOFT COAL BURNED WITHOUT SMOKE

The Commonwealth Edison Company is one of the largest coal consumers in Chicago. It has two enormous plants burning 1,600 tons of coal per day, these figures going up to 2,200 tons after November first. The Harrison street plant, Black Diamond assures us, has been a model of a non-smoke producer for years. It has demonstrated that even Springfield and other comparatively low grade western slacks can be burned absolutely without smoke. A practicable demonstration is given of the theory that, given plenty of head room between the fire and the boiler, smoke can be eliminated absolutely. The amount of head room required is still a matter of controversy, but that is a mere detail. Some of the experts declare that between 5 and 6 feet of head room is sufficient, while others, claiming to be equally expert in the prevention of smoke, declare that 9 feet is essential. The Commonwealth Edison Company has, in its demonstration, taken no chance and has given a good 14 feet between the point where the coal reaches the furnace and the point where the gases come into contact with the cool surface of the boiler tubes. This distance has been sufficient to permit all of the gases to reach a point of ignition and to burn themselves out.

But whatever the method pursued, the result is unquestionable, in that no smoke ever comes from the four stacks of the Harrison street plant of this company, even when firing is the heaviest. It is declared even that the fire can not be forced sufficiently to make the chimneys smoke. This very happy result was brought about by an invention of W. L. Abbott, the man in charge of the operation, who adjusted the fire grate and boiler in a way to produce the results desired. This same device has been promulgated by A. Bement, the mechanical engineer, and smoke prevention expert connected with the Peabody Coal Company.

THE ROBINSON AUXILIARY AUTOMOBILE AIR COMPRESSOR

This little compressor is to be fitted as most convenient on a car and may be driven either by a direct connecting clutch, as shown, to any rotating shaft, or by gears only in mesh when the machine is running, by belt or chain. It supplies air for inflating tires, blowing the "hooter," starting the engine, maintaining pressure on the oil tank, working lifting jacks, regulating oil supply to bearings, etc. This compressor weighs only 8½ pounds; the cylinder is 1¾ in. by 2¾ in. stroke. The bar throws the clutch in or out as required. These compressors are also built in portable and stationary designs, with single and double cylinders for garages, etc. Mr Scott Robinson, 24 Norfolk House Road, Streatham, S. W., London.



AUXILIARY AIR COMPRESSOR FOR AUTOMOBILES.

TEMPERATURES OF THE UPPER AIR

At the recent Congress of German Scientists at Dresden, Saxony, Prof. Hergesell told of his experiments with and records obtained by automatic apparatus sent up to great heights in unmanned balloons. The balloons were sent up in the month of July in different latitudes, and the results were quite surprising and in some respects quite the reverse of what might have been expected. It seemed to be demonstrated that at high altitudes the atmosphere is the coldest over the equator and the warmest over the poles. Balloons which went up to a height of 11 to 12½ miles in the tropics were found to have registered about 148 degrees below zero, Fahrenheit, while in the latitude of central Europe the temperature was only —76 to —85 degrees at the heights indicated. The temperatures do not continually fall with the ascent, the greatest cold being reached at heights of from 6 to 6¾ miles, varying somewhat in different parts of the world. Prof. Hergesell concludes that the atmospheric conditions which affect our weather do not extend higher than seven miles.

COMPRESSED AIR FOR STARTING GAS ENGINES

The following information is taken from the catalog of The Bruce-Merriam-Abbot Company, Cleveland: A gas engine will not start by simply turning on the gas. It must in some way be given several revolutions in order to draw in the proper charge and start the explosions. On cheap engines and in smaller sizes, it is simply a matter of "cranking." Some engine builders use a hand air pump to fill the cylinder for the first time with an explosive mixture and then ignite this with a match. Another method is to prime the cylinder by sucking a little gasoline into the cylinder through the pet cock during a forward stroke of the piston and then backing it up hard against the compression, while some one else trips off the ignition. These methods are, however, partly accountable for the bad name which gas engines have often received, and it is high time that a reliable method were universally adopted.

The method which we use on all engines larger than 12 horsepower is to install an air compressor, which is driven by the engine, and which fills two tanks with air at 200 pounds pressure. To apply this air in starting the engine, we use a device which so shifts the cams operating the valves on the engine, as to enable the use of one of the cylinders as a single acting air engine or steam engine. In this way the starting of the engine becomes as positive and as simple as the starting of a steam plant. The other great advantage of the twin cylinder engine in starting, is self evident from the fact that while one cylinder is acting as an air engine, the other cylinder begins at once to operate as a gas engine. The air valve is then shut off and the cam so shifted as to cause both cylinders to operate as a gas engine. We supply two tanks, either one of which will start the engine half a dozen times. In very large plants where it is desired, a small engine may be used to drive the air compressor, in which case only one tank would be used. Also, where two engines are used to drive dynamos, we install a small motor to operate the air compressor, in which case the air compressor can be operated while either engine is running.

CATHEDRALS AS RECORDS OF ATMOSPHERIC CONTAMINATION

In a report by the Dean of York Minister concerning the recently completed restoration of the west front occurs the following: "It will be well, therefore, if for some time to come the condition of the fabric is regarded not only for ecclesiastical and archæological reasons, but as a token to the citizens generally of what is really the prevailing condition of the atmosphere which they are compelled to breathe and in which they live." This same west front was restored a hundred years ago and other buildings built of the same stone but situated outside of York have suffered no degradation from atmospheric causes, and the Dean argues, citing Faraday, Sir Frederick Treves, Sir Oliver Lodge, Sir William Richmond and others, that the cause of the deterioration of the Minister's front is to be found in "the number of smoke-emitting chimneys throughout York," and that smoke-laden air is as injurious to human beings as to stone buildings. And so this zealous British ecclesiastic argues that as a means of determining the hygienic quality of the circumambient atmosphere, the cathedrals of Great Britain must be kept in artistic and architectural repair.

COMPRESSED AIR
AND EVERYTHING PNEUMATIC
Established 1896.

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THE ELECTRIC AIR DRILL

The Electric Air Drill, the principal features of which are brought to our notice in the paper of Mr. W. L. Saunders in our present issue, seems to be an invention, the applications and consequences, and also the economics and advantages, of which are not yet all revealed. While it completely enables the electric current to be advantageously applied to the driving of the rock drill and its allied devices, so that in most cases the last obstacle to the exclusive employment of electric transmission in mine, tunnel and quarry work, and to large engineering enterprises involving much rock cutting, is removed, it is of not less interest when its pneumatic features are looked into. In fact, the invention after all is more in the pneumatic than in the electric details of its application. The most curious and satisfactory of the results accomplished is in the elimination of the familiar and hitherto unavoidable loss of power which has occurred in the compression of air and in the application of the pressure to mechanical operations. This loss has resulted heretofore from the separating of the apparatus and operation of compression, involving the expenditure of power, from those of the reëxpansion or release of the pressure by which power was realized and work accomplished. In the simplest arrangement hitherto there has been a compressor with all the necessary inlet and discharge valves, then a receiver and a pipe line and at the other end cylinders with other valves and valve operating devices and pistons which carried or operated the ports which did the work. James Watt brought economy of operation to the steam engine by complicating the apparatus employed, adding the condenser and the air pump to the cylinder, and in the development of most of our inventions the tendency has been first to improve them by adding one contraption to another, simplification coming laboriously and slowly later if at all. The Electric Air Drill makes the jump all at once. Receiver and pipe line are thrown away and in operation the compressing cylinder and the reexpanding or working cylinder are made one by the single body of air which at all times fills them both. The heating and increase of volume of the air under compression and the additional uncompensated power entailed for the compression heretofore unavoidable on the one hand, and the loss of power through the cooling and shrinking of the air while doing the work on the other, are both transformed to advantage and the losses are eliminated. There are various other features of the Electric Air Drill inviting investigation before a full understanding and an adequate appreciation of it are attained.

"IT GIVES BACK ALL THE CHANGE"

We probably quite generally appreciate the happy catch phrases which become so familiar and which so jauntily carry the ideas which make things go in the world of advertising. Some of them have been carefully and laboriously molded for their special missions; a common belief, however, is that the best of them have had an apparently fortuitous origin. Their apt suggestiveness or their facility of catching and holding have often been realized afterwards rather than at the instant of their first putting forth.

The better phrase really, and the one ultimately the most telling and successful, is that which suggests some actual and special characteristic or property pertaining to the individual thing spoken of. "It gives back all the the change," as above, carries a positive statement concerning a certain pumping system, and at the same time implies, or practically asserts, that other systems do not give back all the change, or do absorb, dissipate or in some way take more than the power actually requisite for the work and which ought to be expended for it. The phrase thus truthfully and very intelligibly carries both high commendation and severe condemnation. How, if preventable, is mechanical dishonesty any more justifiable than financial dishonesty?

"It gives back all the change" is used as specially applicable to the return-air system of pumping water, and the analogy suggested is well sustained throughout. The operation of elevating water by the expenditure of power, the power being applied either directly or intermediately, is quite similar to the purchasing of goods in the market by the expenditure of money. There is a price which is just and right for anything man may buy, and, similarly, there is also and always a certain expenditure of power which would be exactly right for raising any quantity of water to any given height.

We do not have to go far to find the systems of water raising which do not give back all, or indeed any, of the change, for such systems are most familiar. We speak here particularly of the devices which use compressed air as the medium, the air compressed and used representing the power cost of its compression, just as silver or gold represent the labor cost of their production. In the case of the direct application pump we have first a tankful of water which is to be expelled and driven up through a pipe to the point of delivery. Compressed air is accordingly admitted at sufficient pressure to expel the water, and when the water is thus expelled the tank is full of the air at its full pressure.

We may now imagine the tank to be an engine cylinder with a moving piston, which at the moment is somewhere in the first half of its stroke and at the precise point where cut-off occurs. The end of the cylinder up to the piston is filled with full-pressure air, and this volume of air is the total air expenditure for that engine stroke. In the case of the water tank this volume of air has done all the work that it will be permitted to do, and it is at once discharged. In the case of the engine the equal volume of air, instead of being discharged, continues to do work by driving the piston to the end of its stroke, all the work so done in addition being the change which the direct displacement pump failed to utilize or to return any equivalent for. In the return-air pump the work of expelling the water from the tank is quite similar to the work of the direct displacement pump, but after that the returning of the change occurs, the air, instead of being discharged, being turned into the intake pipe of the compressor, and in its expansion it helps to drive the compressor or to repay the cost of the original compression. This thus told is a simple enough device, but it represents mechanical honesty and profit.—*Cassier's Magazine.*

POWER IN MANUFACTURES

The Bureau of the Census has just issued Bulletin 88, which is a report on the power employed in manufactures. The total power employed in manufactures, in 1904, according to this report, was 14,641,544 horsepower. To this amount steam engines contributed 10,828,111 horsepower, or 73.9 per cent.; water wheels, 1,647,969 horsepower, or 11.3 per cent.; electric power, owned or rented, 1,592,483 horsepower, or 10.9 per cent.; gas or gasoline engines, 289,514 horsepower, or 2 per cent.; and other kinds of power, 283,467 horsepower, or 1.9 per cent.

When compared with the figures reported at the census of 1900, those of 1905 show that in five years the total horsepower increased more than 40 per cent. The power of gas and gasoline engines increased 114.9 per cent. The largest absolute increase however, was reported for steam engines, the horsepower of which increased 2,687,578, or 33 per cent. The power of water wheels increased only 13.3 per cent.

The Middle States ranked first, reporting 5,000,367 horsepower. The Central States, 4,077,298 horsepower; Southern States, 2,386,330; New England States, 2,254,264; the Pacific States, 474,397, and the Western States, 445,937. Perhaps the most striking fact is that the Southern States reported more power than New England. The development in the Southern States has been in the utilization of steam power. In the South 87.4 per cent. of the power was derived from steam and 6.2 per cent. from water, but in New England 59.3 per cent. was from steam and 29.2 from water.

The effect of a heavy industry on the utilization of steam power is illustrated by the fact that Pennsylvania, the principal center of the iron and steel industry, reported 2,088,773 steam horsepower, or almost 20 per cent. of the total for the whole country. Ohio reported 1,028,665, so that these two states have nearly 30 per cent. of the entire steam power employed in manufactures, a fact which results largely from the use of steam power in the metal industries. New York ranked third, with 850,497 steam horsepower; Massachusetts fourth, with 690,467, and Illinois fifth, with 651,578.

The largest amount of water power used in manufactures at the census of 1905 was reported by New York. The capacity in that State increased from 335,411 horsepower in 1900 to 446,134 horsepower in 1905, giving that State 27.1 per cent. of the total for the whole country. The continued leadership of New York in the use of water power is due largely to the utilization of this kind of power in the paper and wood pulp industry. Of the total water power reported by New York at the census of 1905, paper and wood pulp manufactures used 73 per cent.

The next largest utilization of water power in manufactures was reported by the State of Maine, with 203,904 horsepower, followed closely by Massachusetts, with 183,427 horsepower. Wisconsin was fourth, with 112,665 horsepower. In Wisconsin, as in Maine and New York, the paper and wood pulp industry is the largest consumer of water power, while in Massachusetts the cotton and wool industries are the largest.

Besides the power derived from steam, water, electricity, gas and gasoline, 92,154 horsepower was reported at the census of 1905 as owned by manufacturing establishments. A large part of the power included in this class is pneumatic, although probably some hot-air engines also are included. The general introduction of pneumatic tools has resulted in the installation in various shops and factories of large pneumatic plants to supply the compressed air to drive these tools.

CORRESPONDENCE

The Editor of Compressed Air recently received a letter which called for a reply but the signature to which was absolutely undecipherable. The text of the letter was perfectly legible, as was also the address of the writer other than the signature, so that in replying we began our letter, "Dear Mr. What's-Your-Name," and then pasted the signature of the writer upon the envelope. In this treatment of the matter certainly no discourtesy was intended.

Editor Compressed Air:

Unless Mr. John J. Smith can establish an earlier date than 1890, as given in your August issue, for the publication of Johnson's and Church's formulæ for the flow of air in long pipes, the credit of being first to construct a rational formula belongs to Prof. Unwin, for he published his formulæ and gave their derivation in the proceedings of the Institute of Civil Engineers of London for 1875—6 Vol. XLIII.

Since noticing Mr. Smith's communication I have not had an opportunity to look up the formulæ he mentions, so will not attempt to criticise them at this time.

B. C. Batcheller

Editor Compressed Air:

In your October number under the head of "Vacuum Makes a Record" is an item that I don't understand. The unsophisticated are led to believe that you can get a vacuum beyond 15 pounds or 30 inches. I would like to have you explain why you take up valuable space in your paper and the time of your readers with such rubbish. GEO. J. KINDEL.

DIFFERENT VACUUMS

Editor Compressed Air:

The little piece in your October issue about the 400-pound vacuum probably produced a smile on the face of more than one reader, as I suppose was intended, but it occurs to me that under certain conditions a vacuum of 400 pounds might not be such an absurdity after all. It's a curious thing about vacuum and the way we measure and record it. I know well enough about the dictionary definition of vacuum. It's an entire absence of air or anything else. The actual vacuums we know about are only partial differences or deficiencies as compared with fullness or excess of pressure elsewhere. Any partial vacuum, as our gages indicate it, may be reported as more or less without the slightest change of the vacuum itself, but entirely on account of changes of the pressure outside the gage. We ordinarily state a condition of vacuum by its comparison with ordinary atmospheric pressure, but we know that this pressure is constantly changing and varies widely with change of altitude. Comparing external and internal pressures in working with compressed air there are cases where the full atmosphere may itself be considered to be a vacuum.

Perhaps you question this; let's see about it. In the first pumping engines steam filled the cylinder at atmospheric pressure, and then when this steam was condensed, and left only a thin, weak vapor in its place, the atmospheric pressure on the other side of the piston did the work. The air would have been powerless except for the vacuum.

Several years ago when they were sinking the caisson for the central pier of Washington Bridge over the Harlem River, New York City, and had got down nearly as deep as was necessary, an air pressure of 30 pounds being maintained in the caisson to exclude the water, there was encountered some rock which it was necessary to remove. A rock drill was sent down and put to work, and with the aid of some light charges of dynamite after the drilling the rock was soon removed. The curious thing about it was that no compressed air was piped to the drill to drive it. A hose conducted the exhaust of the drill up out of the caisson to the open air, and then upon opening the drill throttle and admitting the air to the drill at the caisson pressure of, say, 30 pounds, this pressure was sufficient to drive the drill piston and do the work required. Here, as in the case of the primitive pumping engine, the air pressure only became effective when the vacuum was secured to weakly oppose it, the vacuum in this case being the atmospheric air at normal pressure.

When this drill was thus being operated by the caisson pressure the vacuum against which it was working might have been measured by an ordinary vacuum gage in the usual way, only that the range of the gage would not have been sufficient for the vacuum to be indicated. A U mercury gage of the familiar type, if long enough, would have done the business perfectly. If one leg of the gage was connected by a tube to the atmosphere and the other end left open then the difference in the heights of the mercury in the two legs would have been about 60 inches, and who wants to say that would not have been 60 inches of vacuum? This would have been the relative or operative vacuum, while the absolute vacuum would of course have been 60+30, or about 90 inches, and this would have been shown if a vertical single-tube mercury vacuum gage, or barometer, without piping to anything, had been used in the caisson.

We have still another and a different illustration of vacuum effect in subaqueous rock work around New York City. In the driving of the tunnels under the North and the East Rivers it was found necessary to maintain a constant pressure in the tunnels sufficient to exclude the water, this pressure depending upon the relative depth of the work below the water surface, and it may here be assumed to have been 25 pounds above that of the normal atmosphere. Rock drills were used quite extensively in these tunnels, but they exhausted into the tunnel atmosphere, or against the pressure, 25 pounds gage, in which the men were working.

As a consequence of this condition two distinct air pressures were maintained in the tunnels during the entire progress of the work, and two separate systems of air compressors and of piping were installed. The low pressure compressors maintained the 25 pounds in which the men worked, the high pressure compressors supplied the air for driving the drills, and as the exhaust of the drills was against an abnormal additional resistance of 25 pounds, the high pressure air to drive them was required to be 25 pounds above that usually employed for ordinary outdoor work.

Allowing 80 pounds, gage, for ordinary drill running, this in the tunnels became 80+25=105 lbs. to do the work with equal effect. In this tunnel work, therefore, there were four distinct levels of pressure in sight, either of which might have been considered a vacuum relatively to that above it, and could have been shown to be such by a vacuum gage of sufficient range and properly connected. The highest, or drill-driving, pressure was 80+25+15, the tunnel working pressure was 25+15, the atmosphere was 15 and then there was the always possible absolute vacuum, 0.

Vacuum—not absolute—is as necessary as pressure to make things go. If a loaded cannon was sunk deep enough in the ocean and fired by wire I don't suppose it would have any effect on account of the absence of vacuum. At a depth of six miles the gases generated would have to have a pressure of over 6½ tons to the square inch merely to overcome the pressure in the muzzle. The actual gas pressures when a big gun is fired are, however, greater than this, so that a much deeper puddle would have to be found to make this true.

TECUMSEH SWIFT.

The regular monthly meeting of the American Society of Mechanical Engineers will be on Tuesday evening, November 12, in the Engineering Societies Building, 29 West 39th street, New York. Mr. Charles R. Pratt will read a paper on the Gearless Traction Electric Elevator as installed in the two highest buildings in New York. The paper will be discussed by engineers and architects from New York, Philadelphia and Chicago. Members of all professions are invited.

QUESTIONS AND ANSWERS

S. A. D., Mount Carbon, Colo. *Q.*: A certain coal mine makes 500 gallons of water per minute, the present head is 500 feet and we must figure on a continuous pumping service; what pumping arrangements, using compressed air, will give the most economical and satisfactory service?

A.: There are two quite different methods which would be suitable. One is the Dense-Air system, using compressed air at a high pressure to drive an ordinary direct acting steam pump, the exhaust being piped back to the compressor at a pressure considerably above atmosphere, by which means "R"—the ratio of compression and expansion—is greatly reduced and a considerable reduction in the thermodynamic losses is effected. See article upon this subject in COMPRESSED AIR for October.

The efficiency of this system depends largely upon the height and the range of pressures used. The use of excessive pressures, however, involves special piping, special pumps and compressors, which thus determine the practical limit. With a discharge pressure of 150 pounds and a return pressure of 85 pounds, both at the compressor, the efficiency between the indicated horsepower in the steam cylinder of the compressor and the indicated horsepower in the pump air cylinder would be about 45 per cent. The ultimate efficiency computed from the water actually delivered would be still further reduced by pipe friction and the mechanical friction throughout, so that not more than 30 per cent. could be expected to be realized.

The other method of pumping spoken of as applicable to the above case is the Return-Air system. The water to be lifted is enclosed in a tank and is expelled and driven up a pipe to the height required by direct-air pressure. After this water has been expelled the air is not discharged into the atmosphere but is returned to the intake of the compressor, its pressure acting upon the rear of the piston and assisting in the work of compression, its expansive force being thus utilized. Usually two tanks are employed, the operations of filling and of expelling alternating in each. By this employment of the return air a large portion of its energy is saved, the principal losses still remaining being the thermodynamic losses and those due to the clearance spaces of the pipes.

The thermodynamic losses can be reduced by cutting down the value of "R," and for this it is proposed to compound the simple return-air system as outlined above, thus reducing "R" to the square root of what it would be between a sufficient pressure for the whole lift and atmospheric intake. This compounding would necessitate the use of two air cylinders, which could be arranged tandem rather than on opposite sides of a duplex machine, on account of the great difference in the two horsepowers.

The clearance space introduced by the air pipes involves a loss which bears a certain proportion to the percentage of this clearance as compared with the volumes of the tanks. The longer and larger the pipes the larger will the tanks have to be to realize a given efficiency. An efficiency as high as 40 to 45 per cent. we are assured could be guaranteed.

In the compound system the water from the first pair of tanks would be delivered to the second pair under a certain pressure, the latter delivering against the final pressure. As a second-stage tank would not be ready to receive water at the beginning of a cycle, provision would have to be made for an intermediate storage of either the water or the air, and this could be done either by providing a sump part way up the shaft, where part of the water could ascend temporarily, returning when the second-stage tank was ready to receive it, or the delivery of the water from the first-stage tank could be temporarily deferred until the second-stage tank was ready to receive it, the charge of air for expelling the water being meanwhile pumped by the compressor into a receiver so large that it could receive this charge without a rise of pressure of more than 10 or 15 pounds. The work done on the air in raising it to this higher pressure would not be entirely thrown away as the water would be delivered to the second-stage tank at this higher pressure, and the pressure on the returning air of the second stage acting against the compressor piston would be maintained for a longer period and at a pressure in excess of the normal filling pressure of the second stage, thus giving up to the second-stage cylinder a large part of the apparently unnecessary work done by the first-stage cylinder. M. W. SHERWOOD.

W. M. S., Batson, Texas. *Q.*: I wish to raise a valve off its seat, with a wound soft iron horse-shoe magnet, against a pressure of 120 pounds per square inch. The orifice is one-quarter of an inch. Will you kindly give me the dimensions of a magnet which will be sufficiently strong to do this work? As I will want to use several hundred of them from one general station, how many of them can be run per horsepower?

A.: As this is a question for an electrical expert we will not attempt to answer it. Probably no one could be found to reply who would not ask several questions. To begin with, what is the required valve movement and total weight of the valve and stem or other part to be moved? Is the valve in air or in water and would the magnet be located inside or outside the valve chamber? Would the face of the magnet be in actual contact with the valve or stem and move with it in opening the valve or would the magnet be located at a distance equal to the valve lift and the valve be expected to jump to the magnet every time it was lifted? Why use a horse-shoe magnet?

These queries are here intended as hints for other inquirers. Please give particulars and if necessary sketches also, so that a reply may be expected to fit the case.

TRADE PUBLICATIONS

Applications of Thermit in Foundry Practice and Butt Welding by the Thermit Process. — Goldschmidt Thermit Company, New York. Each 12 pages, 6x9 inches; illustrated.

The United Service & Tube Company, Boston, issue a pamphlet describing their system of foot power pneumatic tubes for store and office transmission. No power is required except the pressure of the foot.

Extra Heavy Valves.—12 pages, 5¼x7¾ inches, illustrated. Describes and gives dimensions of a full line of globe, check and other valves for pressures of 300 pounds. Made by Jenkins Bros., 71 John Street, New York.

Efficient Bearings.—Franklin Filter Co., St. Louis, Mo.—16 pages, 6x9 inches, illustrated. Describes the Franklin Oil Filter and explains numerous applications of it, including a complete system of automatic lubrication for large plants.

Morris Metallic Packing.—Catalog No. 110 of the H. W. Johns-Manville Co., New York. 16 pages, 4½x7 inches, illustrated. Shows the different styles and applications of this make of metallic packing with directions for dimensioning and applying.

Modern Welded Pipe.—National Tube Company, Pittsburg, Pa.—32 pages, 6x9 inches, large number of halftones. This attractive pamphlet gives an outline of the progressive operations in the manufacture of steel tubing from the ore to the finished product.

The United Service & Tube Company, Boston, have entered the field for the manufacture and installation of Pneumatic Tube Service for carrying cash, messages, packages, etc.

They have issued a little circular giving the records of the four principal officers.

The Belt Book.—A Magazine for the Users of Belting, September, 1907. Published by Chas. A. Schieren & Co., New York City. 20 pages, 10x7½ inches, illustrated. Contains a variety of interesting matter concerning The Tanners of Nieuw Amsterdam, leather and belting.

The Expanded Metal System of Steel Concrete Construction, Expanded Metal Engineering Co., 225 Fifth Avenue, New York. 176 pages, 5x8 inches. Numerous halftones with tables and general practical information concerning this valuable element in modern construction.

The Independent Pneumatic Tool Company, Chicago, New York.—Catalog No. 8. 80 pages, 6x9 inches; more than 100 half-tones. Describes the entire line of *Thor* Pneumatic Tools and illustrates their various applications. Tables of dimensions and capacities of the several sizes make the information complete.

The Hanna Engineering Works, 820 Elston Avenue, Chicago, have issued a circular illustrating their line of Hanna Riveters and describing the peculiar mechanical movement employed whereby a uniform maximum pressure is exerted throughout the last half of the piston travel, thus giving hydraulic results with a pneumatic apparatus.

Can You Use a Small Air Compressor? Ingersoll-Rand Co., 11 Broadway, New York; 20 pages, 3¼x5¾ inches, numerous half-tones. This handy leaflet tells about the Imperial, Type Eleven, compressors built by this company. These machines are vertical, belt or motor driven, having air cylinders either duplex or compound with normal free air capacities ranging from 8 to 500 cubic feet per minute and for any pressure up to 100 pounds. The adaptability and popularity of these machines is attested by the list given of 120 different lines of service in which they are employed.

SAND BLASTING BEFORE PAINTING

At the recent annual meeting of the Master Car and Locomotive Painters' Association an elaborate report was presented upon the Painting of Steel Passenger Cars. The following concerning the cleaning of the surfaces before the painting is of interest to our readers:

Before any protective coatings are applied, all oil, grease, dirt, scale and rust should be entirely removed, and a priming coat applied before additional rust forms on the surface. This may be accomplished in several ways, the treatment being varied according to the condition of the metal, and the conditions under which the work is done. The oil and grease may be removed by benzine or turpentine and wiping with rags or waste. Scale and rust can be most thoroughly removed by the sand blast, or by dipping the parts in a sulphuric acid bath, and rinsing with water. Conditions may be such that certain parts cannot well be cleaned by the best methods and in such cases scrapers and wire brushes may be used to advantage. For cleaning all exposed parts, however, we strongly urge the use of the sand blast; also for interior parts that are to be coated.

NOTES

During July 19.38 miles of holes were drilled on the Panama Canal work, as follows: Steam and air rock drills, 55,290 feet; well and mechanical churn drills, 34,246 feet; hand drilling, 12,789 feet.

In France the depth of drill holes for blasting is restricted to 1½ meters, or about 5 feet. The miner is forbidden to touch a hole after it has once been fired and when a shot is missed, the hole must be drilled over.

An investigation of manhole explosions at Aberdeen, Scotland, disclosed the fact that coal gas leaking from street mains may become odorless by filterng through a moderately thick layer of earth without losing its explosive condition.

In consequence of the official inquiry into the causes of the Courrieres catastrophe, the French minister of public works has decided that mines must be provided with breathing appliances, ready for immediate use, and permitting their wearers to remain at least an hour in an inrespirable atmosphere.

In the upper right hand corner of meters used for measuring natural gas is a little dial by which it can be determined if there is a leak in the household plumbing. When no gas is being used for any purpose the hand upon this dial should be still, and any movement of it is sure evidence of leakage in pipe or fittings.

Russian units of weights and measures are complex. For instance, 1 pood is equivalent to 36.1128 pounds avoirdupois, or 526.645 ounces troy, or 16.38 kilograms. One funt equals 0.9028 pound avoirdupois, or 13.166 ounces troy, or 409.512 grams. One sajene equals 2.1336 meters. One archine equals 0.7112 meter.

A gasworks on the shore of Lake Constance, Switzerland, supplying the town of St. Gall, six miles away, is in the happy position of being able to sell and deliver a greater volume of gas than it makes. The factory happens to be situated 820 feet lower than the holder and the place where the gas is consumed, and as the gas rises it of course expands before it is delivered.

They are certainly making the dirt fly in the Canal Zone. The following is the August record for the steam shovels: Culebra division, 786,866 cubic yards; Gatun lock site and spillway, 105,223 cubic yards; Mindi, 15,527 cubic yards; La Baca, 6,784 cubic yards; Chargres division, 2,280 cubic yards. The dredges at the Colon terminal excavated 189,170 cubic yards and at the Pacific terminal 168,284 cubic yards. Here is a total for one month of 1,274,404 cubic yards.

The French Government has approved the system of submarine signalling, and has ordered submarine signal bells, actuated by pneumatic power, to be placed at the ends of the piers at Calais, Boulogne and Havre, and a submarine signal buoy to be placed for trial off Havre. A submarine signal bell has been fitted to the Sandette lightship, off Dunkirk, for some time. When these bells are working there will be practically a continuous system of submarine signals from Havre to the Elbe.

Considerable progress is being made in Europe in turbine air compressors, Professor Rateau having constructed machines which compress air to six and even seven atmospheres, and fifteen compressors varying from 800 to 2,000 horse-power are now on order. The efficiency of these machines is said to be of the same order as that of piston compressors, and, contrary to what might be expected, the machines possess great flexibility in output. The machines are compounded, compressors with a single wheel being only suitable for an outlet pressure of about one-half atmosphere.

In California a contract has been let for the building of a rifled oil pipe line 256 miles long. Spiral indentations in the interior of the pipe, 8 inches in diameter, cause the liquid column to rotate as it flows, and a small percentage of water being added to the oil, this, being heavier, is carried to the periphery and forms a lubricant, greatly reducing the friction and allowing the core of oil to glide easily. There will be twenty-three pumping stations on the line and it is estimated that 23,000 barrels of fuel oil can be delivered every twenty-four hours, which would require a constant flow of two and one-half miles an hour.

While a compressor and the attached piping system were being tested recently at the new plant of the Woodruff Ice Company at Peoria, Ill., the discharge chest on the left-hand cylinder burst and badly shattered the ⅝-inch cast-iron water-jacket surrounding the cylinder. The erecting and the operating engineers were both somewhat injured. The gage at the time of the accident showed only 240 pounds, whereas the machine had been tested on the day previous to 300 pounds, and in the shop to 500 pounds. It is, therefore, surmised that the fracture was due to an explosion of oil vapor due to the heat generated by compression, there being no circulation in the water-jacket at the time.—*Power.*

Direct-acting steam pumps, both single and duplex, are largely used through the mining fields. They are extravagant in the consumption of fuel even under the best of conditions, and are liable to great additional losses from the use of leaky steam valves and pistons. Careful tests under favorable conditions, and the data obtained from actual practice show the following consumption of steam or fuel per horse-power per hour: Triplex power pumps require 1½ to 5 pounds coal per horse-power per hour; small steam pumps, 25 pounds; large steam pumps, compounded, 13 pounds; pulsometer pumps, 60 to 70 pounds; injectors and inspirators, 100 pounds per horse-power per hour.

It is a peculiar function of a fan blower that instead of always delivering a fixed volume of air, regardless of requirements, it automatically increases the volume as the resistances are decreased. On the other hand, if the blower be in operation with a fairly free outlet, in excess of its capacity area, and that free area be decreased, the pressure produced will immediately rise, thus tending at once to overcome the increased resistance. Therefore, if a certain maximum pressure is known to be required, the fan may be so speeded as to give this at such times as the conditions demand; while at other times, when less pressure or volume of air is required proper manipulation of the blast gate will economize power.

The dimensions and powers of gas engines would seem to be approaching the limit in the United States as well as in Europe. Cylinders 44-inch diameter and 54-inch stroke are under construction by the Allis-Chambers Co. for the power houses of the Indiana Steel Co., at Gary, Ind. The engines are four cycle, twin-tandem, direct-acting, designed to give 4,000 horsepower on blast furnace gas of 80 to 85 b. t. u. and up to 5,000 horsepower on richer gases. They are intended for direct connection to alternating-current generators. The crank pins are 20 inches in diameter, the shaft 30 inches and the fly-wheel 23 feet. The fly-wheel weighs approximately 200,000 pounds and the entire engine, roughly, 1,500,000 pounds.

In drilling for a small rock cut on Manhattan Island, New York, the work was done by hand. Two strikers and a holder average 15 feet per ten-hour day. Each hole was 7½ feet deep, the starting bit being 1⅞ inches and the finishing bit 1¼ inches. The rock was a tough mica-schist. Each man averaged 5 feet of hole per day, which is equivalent to 40 cents per lineal foot when wages are $2 a day. The holes were spaced very close together, averaging only 2½ feet apart. Hence it required 4.3 lineal feet of drill hole per cubic yard excavated, which, at 40 cents per lineal foot, made the cost $1.72 per cubic yard for drilling alone. The job was being done on a percentage basis, which may account, in part, for the fact that the contractor permitted such close spacing of the drill holes. As a matter of fact, small as the job was, it would have paid handsomely to have installed a steam drilling plant. The cost given does not include the cost of sharpening the steel or carrying it to and from the blacksmith shop.—*Engineering-Contracting.*

It is an encouraging sign of the times that even coal mines are beginning to appreciate the value of coal and to practice the familiar economies even at the mines. Not only is the coal that is saved worth the saving but the initial cost of boiler plant and the reduction in the labor item, in connection with the greater reliability and the reduced cost of maintenance constitute a large aggregate reduction of operating expense. The power plant of the Berwind-White Coal Company at its No. 40 mine seems to leave little to be suggested. The mine is operated entirely by compressed air and electricity, and the power plant comprises two Ingersoll-Rand Corliss air compressors and three generator units direct connected to Cooper-Corliss cross compound engines. The steam cylinders of the compressors are 20 and 40 and the air cylinders 34¼ and 22¼ inch diameter by 36 inch stroke. A gravity oiling system serves the entire plant. A battery of Stirling boilers maintains a steam pressure of 150 pounds and a barometric condenser gives a constant vacuum of 24¼ inches.

Power transmission from waterfalls has been rapidly and remarkably extended in the Southern States. The Catawba is a particularly interesting example. This stream, having its origin near the foothills of the Blue Ridge Mountains, is hardly to be termed a large river, yet it has been "harnessed" to an extent that is significant of the results that can be accomplished in this direction. Beginning near the headwaters of the river, there are the Rodhiss cotton mill, 1,500 horsepower; the Long Island mill, 300 horsepower; Monbo mills, 150; Mountain Island, 1,000, and Tuckaseegee, 250 horsepower. The Catawba power plant develops 10,000 horsepower, and the Great Falls plant 30,000 horsepower. On the south fork of the river, over 3,000 horsepower is utilized entirely for cotton-mill operation. A few miles below the Great Falls plant work is in progress on the Rocky Creek plant, with 20,000 horsepower, and above Great Falls a 15,000 plant is to be erected. The plants complete, underway, or yet to be developed, require about $250,000 a month outlay. The latest estimate is that there will be 140,000 horsepower in use alone in a radius of 70 miles from Charlotte, N. C.

Electrical air filtration is suggested by an experimenter, who has discovered that a body positively electrified to 100 volts or over will, if placed in a sooty atmosphere, become covered with soot in a day, while a negatively charged body remains comparatively clean. In an application of this discovery to the fan intake of a ventilating system, a sheet of wire gauze was inserted in the intake flue, and electrified by connection to the positive of a 250-volt main. The gauze is reported to have extracted large quantities of soot from the air.—*The Engineer* (London).

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, Pa.

September 3.

864,810. HUMIDIFYING APPARATUS. John Taylor, Manchester, England.

864,918. AUTOMATIC AIR-PUMP. Edward J. Rohrbacher, Blaine, Wash.

865,014. DISCHARGE-VALVE FOR FLUID-COMPRESSORS. Niels A. Christensen, Milwaukee, Wis.

865,015. COMPRESSOR. Niels A. Christensen, Milwaukee, Wis.

865,130. APPARATUS FOR RAISING SUNKEN VESSELS. Ffrdando Staud y Ximenez, Chicago, Ill.

865,210. AIR-BRAKE APPARATUS. William T. Robinson, James W. Neighbours, and Wilbourn O. Pierce, Pulaski, Va.

865,218. AIR-SUPPLYING MEANS FOR EXPLOSIVE-ENGINES. August Wagener, Berlin, Germany.

865,333. PROCESS OF SMELTING ORE AND CONVERTING MATTE. Arthur M. Day, Bingham Canyon, Utah.

The process of smelting ore and converting matte, consisting in forcing air into the charge and injecting powdered silica or silicious material in a fluent form through one or more twyers with an air blast separate and distinct from the air supply to either twyers, substantially as described.

865,337. PNEUMATIC TOOL. Frederick S. Graham, Philadelphia, Pa.

September 10.

865,388. CONTROL OF AN ELECTRICALLY-DRIVEN AIR-COMPRESSOR. Ebenezer Hill, Norwalk, Conn.

865,389. CONTROL OF ELECTRICALLY-DRIVEN AIR-COMPRESSOR. Ebenezer Hill, Norwalk, Conn.

865,390. MEANS FOR UNLOADING AIR-COMPRESSORS. Ebenezer Hill, Norwalk, Conn.

865,424. AIR-COMPRESSOR. George C. McFarlane, Bay City, Mich. Filed March 28, 1906.

865,496. COMPRESSED-AIR MOTOR FOR AUTOMOBILE. Fred G. Herrington, Decatur, Ill.

865,615. AIR-BRAKE HOSE-COUPLING. Eugene W. Shaw, Weir, Kans.

865,622. NUT AND BOLT TURNING ATTACHMENT FOR PNEUMATIC HAMMERS. Charles Wilson, Chicago, Ill.

865,767. APPARATUS FOR SUPPLYING EXPLOSIVE-ENGINES WITH EXPLOSIVE MIXTURE. Charles G. Dean, Indianapolis, Ind.

865,941. PNEUMATIC TRACK-SANDER. Henry Rau, Jr., Baltimore, Md.

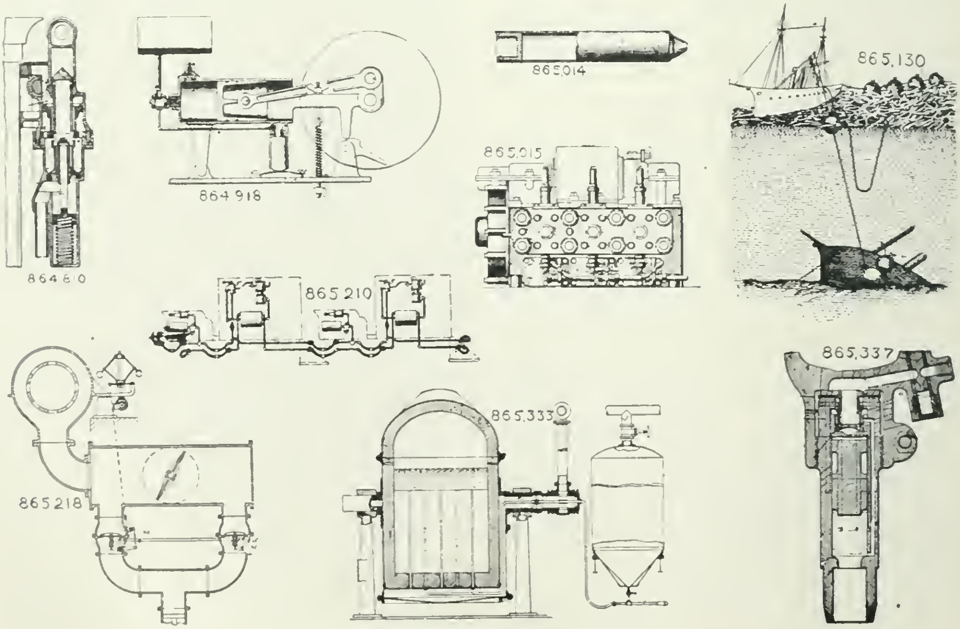
865,942. PNEUMATIC TRACK-SANDER. Henry Rau, Jr., Baltimore, Md.

865,949. VALVE FOR FLUID-PRESSURE ENGINES. William C. Schaff and Jacob A. E. Friederichs, San Bernardino, Cal.

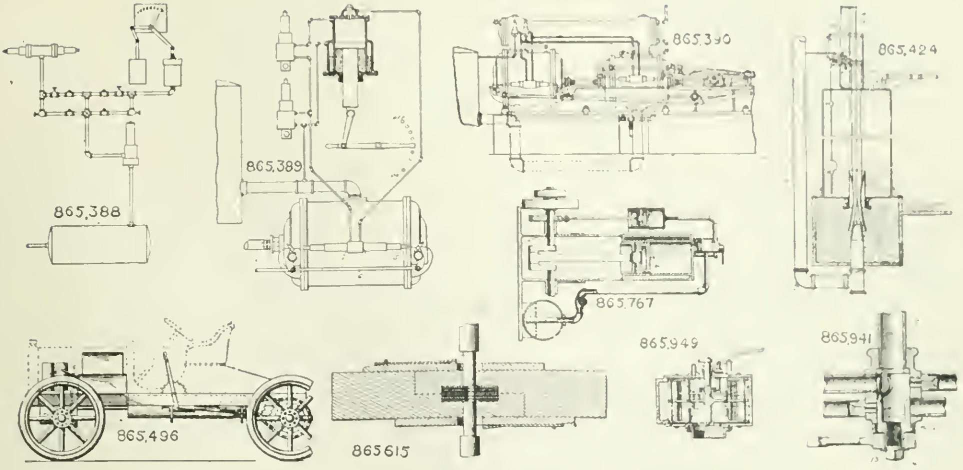
September 17.

866,041. DEVICE FOR SHARPENING ROCK-DRILLS. Elias Lewis, Denver, Colo.

866,171. ELASTIC-FLUID TURBINE. George Westinghouse, Pittsburg, Pa.



PNEUMATIC PATENTS, SEPTEMBER 3.



PNEUMATIC PATENTS, SEPTEMBER 10.

866,336. PNEUMATIC PIANO-PLAYER. Joseph Courville, Detroit, Mich.

866,348. MEANS FOR RAISING SUNKEN VESSELS. George Fearon and Christopher S. Fearon, Newcastle-upon-Tyne, England.

866,361. DRILL ATTACHMENT. Wilber R. Hitchcock, Cornwall, Ontario, Canada.

866,370. PNEUMATIC TOOL. Herman Leineweber, South Chicago, Ill.

866,415. PNEUMATIC SEPARATOR. Andrew M. Anderson and Cornelius Quesnell, Moscow, Idaho.

866,448. PRESSURE-GOVERNING DEVICE FOR PUMPS. Clyde C. Farmer, Chicago, Ill., and Walter V. Turner, Wilkinsburg, Pa.

866,457. COMPRESSED-AIR INSTALLATION. George J. Gibbs, Bamber Bridge, England.

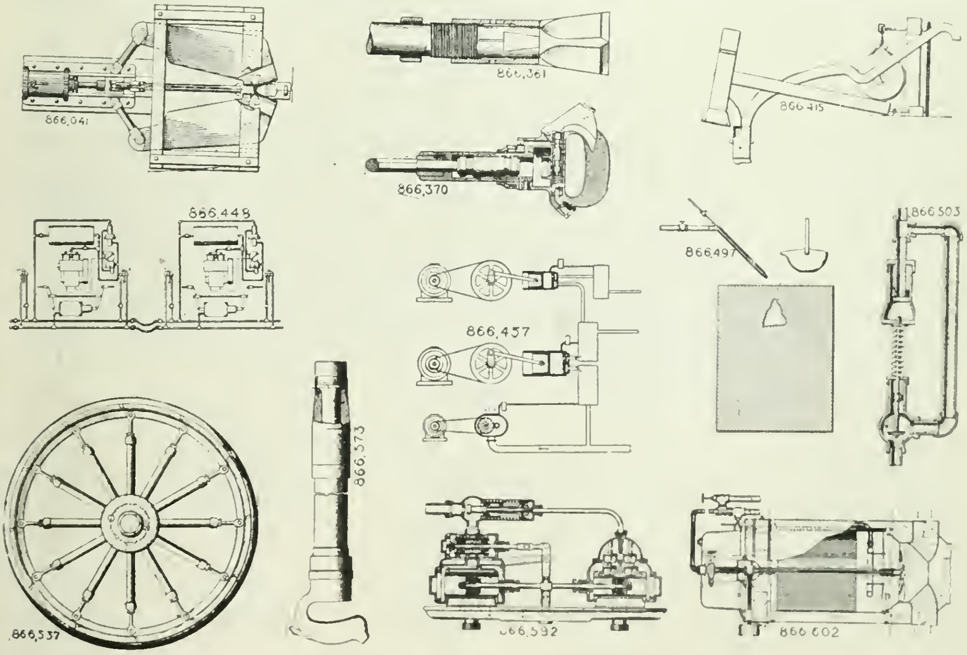
866,497. PROCESS FOR DOING AWAY WITH BLOW-HOLES AND LIKE FLAWS IN CASTINGS. Adolph E. Menne.

A process for doing away with hollows in castings, consisting in suitably placing the same, then applying an oxidizing gas under pressure to the top surface of the casting, then suitably starting the combustion of the gas and then partially igniting and melting the material of the casting and ejecting the material until the hollows are reached and then filling up said hollows with liquid metal, substantially as described.

866,503. FLUID-PRESSURE REGULATOR. Andrew J. Morehart, Fostoria, Ohio.

866,515. AUTOMATIC AIR-DAMPER. Arthur W. Puddington, Cleveland, Ohio.

866,537. PNEUMATIC-SPOKE WHEEL. Arthuer H. Thibault, Valparaiso, Ind.



PNEUMATIC PATENTS, SEPTEMBER 17

866,573. PNEUMATIC HAMMER. Joseph Boyer, Detroit, Mich.

866,591. FLUID-MOTOR. Hugh W. Kimes, Dayton, Ohio.

866,592. FLUID-MOTOR. Hugh W. Kimes, Dayton, Ohio.

866,602. AIR-TREATING MACHINE. Charles A. Rumble, Boston, Mass.

September 24.

866,623. VALVE-GEAR. William H. Collier, Jackson, Tenn.

In valve gear, the combination with a plurality of fluid-pressure-actuated valve-operating means, of a controlling valve for the same having ports adapted to register with ports of said valve-operating means, means for driving said controlling valve, and fluid-pressure means for shifting said valve in a direction other than that of its normal motion, said valve comprising means whereby when the valve is so moved in a direction other than that of its normal motion, the operation of said fluid-pressure-actuated valve-operating means is varied.

866,643. PRESSURE-CONTROLLER. James H. Glenn and Michael Reule, La Fayette, Ind.

The combination with the receiver of an electrically-driven compressor, a cylinder in communication with the receiver, a plunger working in the cylinder and spring-actuated to oppose the receiver pressure, and a plunger-stem: of a block carried by the plunger-stem and having an opening, a stem working in said opening and carrying circuit-closing means, a yielding connection between the plunger-stem and the circuit-closing stem at both ends of the aforesaid block, tensioned latches opposing the movement of the circuit-closing stem, the tension of said latches being greater than the yielding connection between the plunger-stem and the circuit-closing stem, and latch engaging means carried by the circuit-closing stem.

866,720. PNEUMATIC DRILL-FEED. George H. Gilman, Claremont, N. H.

866,804. PNEUMATIC CONVEYER. Samuel Olson, Chicago, Ill.

866,837. RELIEF-VALVE FOR TENSION-RESERVOIRS FOR PNEUMATIC APPARATUS. George P. Brand, New York, N. Y.

866,878. AIR-COMPRESSOR. Alexander McCarthy, New York, N. Y.

In an apparatus for the compression of air, the combination of an oscillating cylinder partially filled with fluid, means for oscillating said cylinder, a series of air compressing devices and said oscillating cylinder for the purpose specified.

866,922. ENGINE. William O. Duntley, Chicago, Ill.

866,930. AIR-STRAINER FOR SUCTION-VALVES. Maury W. Hibbard, Chicago, Ill.

866,981. PNEUMATIC TOOL. Joseph H. Templin, Philadelphia, Pa.

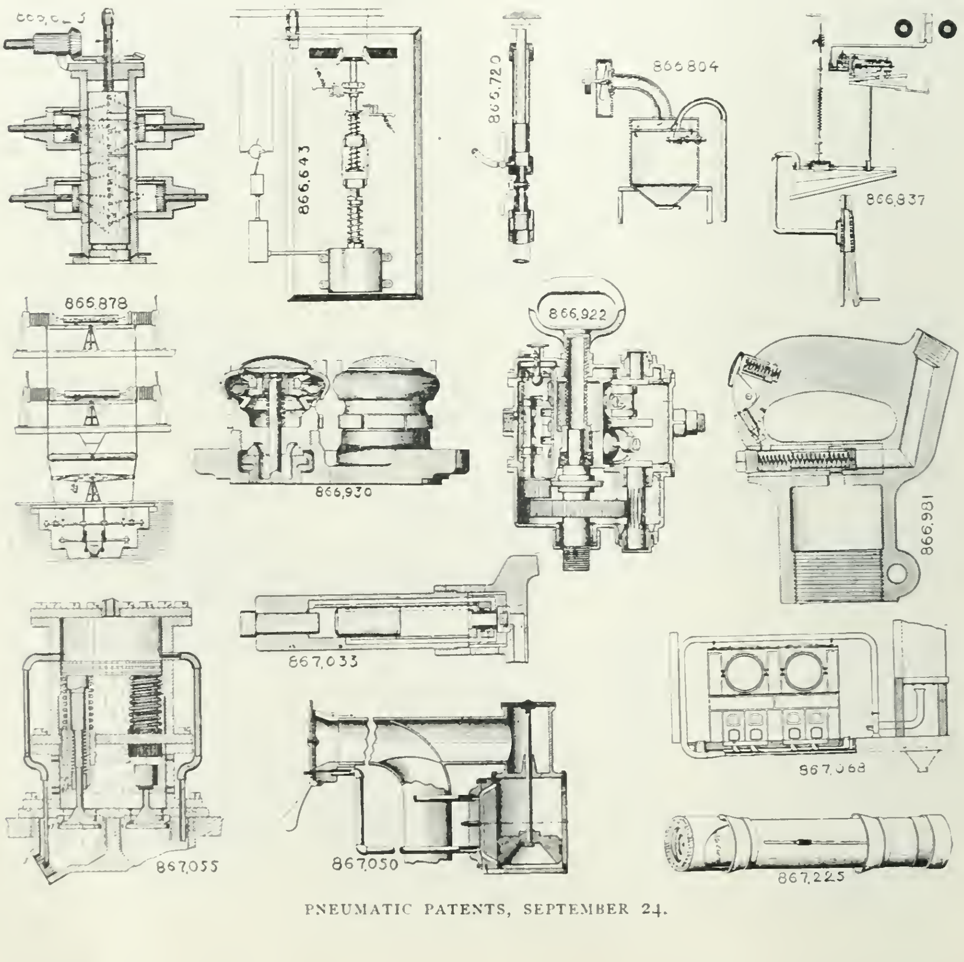
867,033. FLUID-PRESSURE POWER-HAMMER. Carl R. Green, Dayton, Ohio.

867,050. PNEUMATIC-DESPATCH-TUBE APPARATUS. Frank W. Knott, St. Louis, Mo.

867,055. AUTOMATIC AIR SANDING-MACHINE. Albert F. Kubicek, Chicago, Ill.

867,068. PNEUMATIC DELIVERY SYSTEM. William McClave, Scranton, Pa.

867,225. CARRIER FOR PNEUMATIC-TUBE APPARATUS. William A. Brown, Chicago, Ill.



PNEUMATIC PATENTS, SEPTEMBER 24.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. XII DECEMBER, 1907 No. 10

CAISSON WORK FOR THE PARIS SUBWAY

The built or projected lines of urban transit in Paris cross the Seine five times upon bridges of various design. One line, however, traversing the central portion of the city, passes under the river, and its construction has involved the sinking of metallic caissons of large size and of unusual design. The plan first proposed was to have two separate tunnels driven at a suitable depth by the compressed air shield system. This would have necessitated the adoption of a level at least ten feet lower than was required for the system adopted, while at the same time the latter would permit the use of a single tube for both tracks instead of a separate tube for each.

The tunnel was formed by sinking a number of caissons in the bed of the river and connecting them to form the continuous tube required. Altogether three distinct methods of construction were used for the line. For the shore sections, running to a certain distance from the banks, the tunnel was built or driven by the aid of a compressed air shield, and, as the second method, the caissons were sunk in the bed of the river to the required depth and in correct positions to connect. A third method is to be used later when the work is carried under the line of another road already built and in operation. To prevent any sinking of the road above it at this point, the freezing process is to be employed. There is an island in the River Seine, with a passenger station

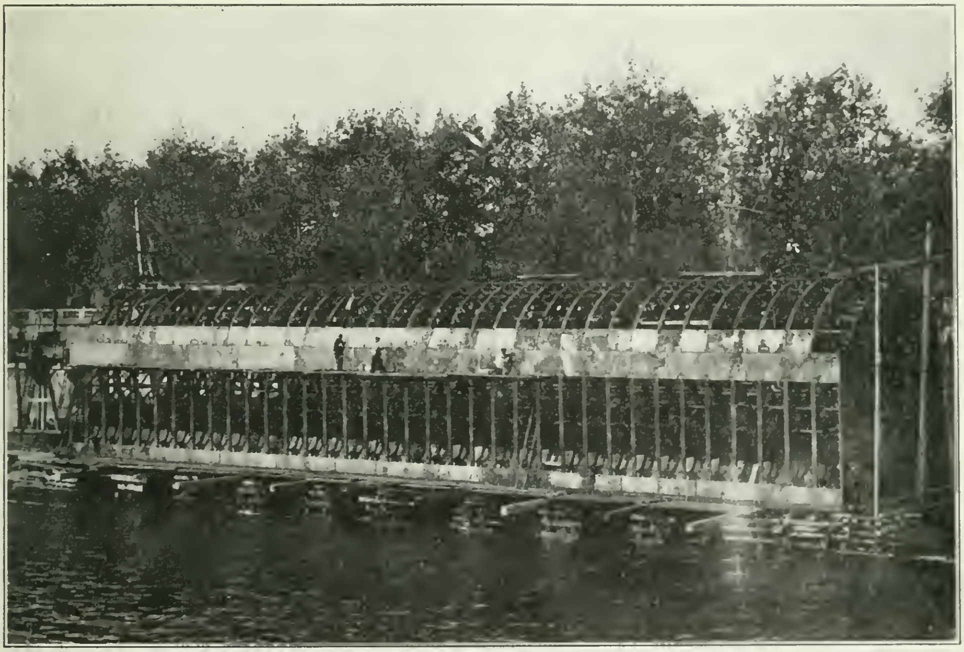


FIG. I. SIDE VIEW OF PARIS TUNNEL CAISSON.

for the subway line, the station also being formed by the sinking of a group of immense caissons between the ground and water levels. There are three sections of the tunnel caisson in the large arm of the river and two sections in the narrower arm.

The half-tones show clearly the caisson construction. Each section is formed of two principal parts, the tunnel proper and an outer framework which forms the actual caisson. The tunnel is approximately elliptical in section and is composed of iron rings. Each ring is made up of a series of cast iron voussoirs bolted together and the rings then bolted to each other with layers of treated wood between for a water-tight packing. Around this elliptical tube is built a metallic shell which in the lower part of it forms the rectangular caisson. The frame of this shell is formed of a series of curved ribs of channel bar outside the tunnel tube and braced at a certain distance from and nearly parallel with it by cross braced iron work. These ribs do not run around under the elliptical tube, but, passing the center or horizontal axis, they extend vertically downward, thus forming the sides of the caisson, and extending some distance below the bottom of the tunnel tube they thus form the compressed air chamber in which the men work to make the necessary excavation to allow the structure to sink to the required depth. Over the ribs is placed a sheet-iron covering which forms an external air-tight shell, the ends also of the caisson being thus closed.

The caisson is floated and towed to its place, piles being driven to guide it vertically during the sinking operation. The semi-elliptical space between the tunnel tube and the sheet-iron sides is filled up with cement beton, the top plating having been left off for the purpose. As the ground is excavated within and under the caisson it is gradually lowered to its proper level below the river bed, the tunnel tube having been ballasted with water to give the needed weight and steadiness. When finally in place the caisson is filled with concrete, the shafts at the side, with the air locks for the passage of men and material, are removed, and after all the connections are made the water is pumped out of the tunnel tube. The ends of the caissons lie about five feet apart, and this space is filled by a small caisson which is sunk last. The removal of the end plates of all the sections leaves the continuous tube.

There is a double pneumatic interest in this undertaking, as compressed air was employed not only in the sinking of the caissons, but also in their construction, both of the half-tones showing Haeseler pneumatic riveters in use upon the frames and shells.

REFRIGERATION AS A SUPPLEMENTARY FUNCTION OF THE POWER PLANT

By Joseph H. Hart, Ph. D.*

Refrigerating machines may be classified into three groups: those employing air as a refrigerant; those employing the mechanical phenomena of absorption and solution of ammonia by water, and those using liquefiable gas. The air machine is clean and odorless and is somewhat in use on shipboard. It utilizes the process known as balanced expansion, whereby the air is cooled by doing work in a cylinder. Its size, weight and cost and large consumption of power are serious drawbacks to its wider use, and it is now recognized that its field is limited to places where the use of other types is prohibited.

The absorption machine has a rather complicated mechanism. There are no moving parts except a small slow speed pump and it possesses a distinct advantage on this account. Its agent is ammonia and it was generally regarded up to about the year 1895 as an extremely inefficient process.

The liquefiable gas machine was considered the most efficient, the simplest and most convenient. A gas was liquefied by mechanical compression, followed by cooling; this liquid was then allowed to evaporate and absorb its latent heat of liquefaction from surrounding bodies, and the process was made continuous.

The absorption machine, so-called, which utilized water in conjunction with ammonia gas, was the first practical refrigerating machine; but later it came into considerable disrepute on account of its remarkable inefficiency. The gas was produced from the aqua ammonia by steam coils in a generator somewhat similar in construction to the modern boiler. The pressure was increased by means of heat until the gas could be liquefied with cold water, and it was then evaporated in a manner identical with that of the ammonia compression type.

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*Abstract from Cassier's Magazine.

The expanded gas, instead of being conveyed into a compressor, as in the latter system, was absorbed by cold water or weak aqua ammonia. This system requires five distinct units: the generator, where the gas is produced; the dehydrator, where the excess water vapor carried over by the gas is condensed and removed; the condenser, which consists of pipes having cold water flowing over them and in which the gas is changed to ammonia liquid; the expansion coils or shell cooler, in which the refrigeration is produced; and the absorber, which absorbs the gas back into the weak aqua ammonia. Further, an ammonia pump must be installed to force this liquid back into the generator, thus making the process continuous.

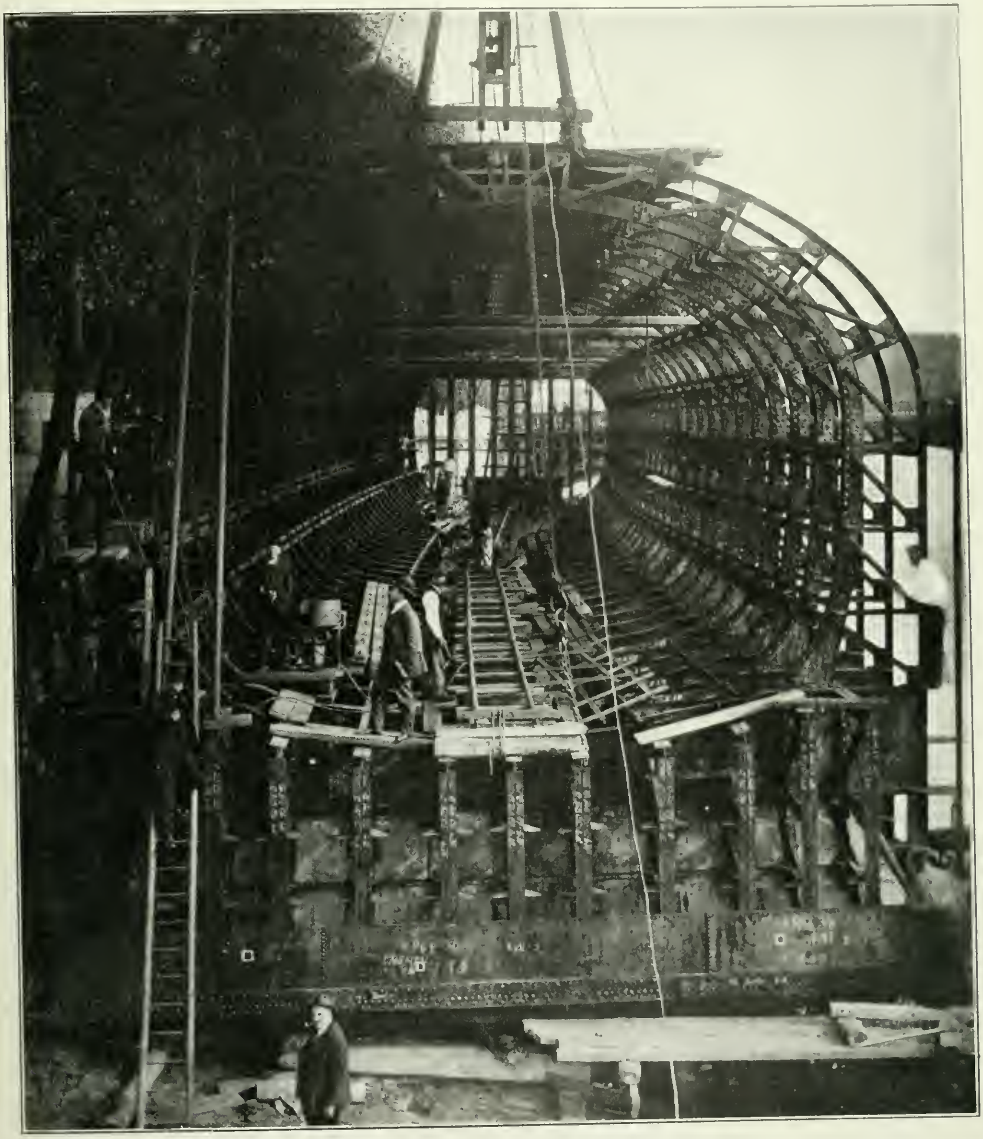

FIG. 2. END VIEW OF PARIS TUNNEL CAISSON.

The compression system, on the other hand, utilizes simply a compressor and condenser and the refrigerating apparatus or shell cooler.

This mechanical compression type was formerly superior, although it depends on the operation of a compressor which is mechanically of low efficiency. Both types of machines, however, are dependent for their efficiency upon design to an extent which was not realized until recently, and the situation exists to-day that the absorption system is the superior in many ways when used in large units.

The absorption system has its efficiency limited directly by the action of the dehydrator. If water vapor is carried over with the gas and not separated, it condenses in the condenser in the production of liquid ammonia and combines there directly with it, forming strong aqua ammonia; the refrigerating power of the ammonia being counterbalanced by the heat of combination at this point. Thus the entire problem in the absorption system depends upon the design of the generator and its efficiency in producing rapidly comparatively pure ammonia gas without water vapor, and upon the efficiency of the dehydrator in removing the residue of the water vapor before it becomes objectionable. The design of the absorption system was not fully studied until within the last decade. Machines of both types depend absolutely for their efficiency on their design. An absorption plant may operate with a production of no refrigeration and a compression plant may do the same.

The absorption machine employs the latent heat in the steam for the production of ammonia. A compression type utilizes the expansive force of steam only, and hence superheated compound condensing engines are the rule in large installations of this type. We thus come to the anomalous condition that the absorption machine can utilize exhaust steam very efficiently, whereas the compression plant does not utilize the heat of the exhaust at all. The claim is often made that the absorption machine requires more heat in its operation than the compression plant, and while this is true, when the quantity of heat taken from the boiler is considered the absorption system is still much superior. Thus in large units—in the production of ice, for example—a compression plant operates generally on an 8 to 1 basis; that is, 8 tons of ice produced to 1 ton of coal consumed. An absorption system under the same conditions can operate on an 11 to 1 basis, whereas a combination plant of the same total capacity for compression and for absorption, the exhaust steam from the compressor operating the absorption system, will operate on a 14 to 1 basis. These figures in general have a 50 per cent. range of applicability, depending upon maintenance of plant and method of operation; but there is no doubt, in large units of 100 tons capacity or more, that the absorption system, or, better, a combination plant is much superior. This is in complete contradiction to the generally accepted opinion ten years ago, and is due to improvement in design of the absorption system.

This brings us to a remarkable condition in the engineering field. It shows a further application of the utilization of exhaust steam never before seriously considered. Exhaust steam has been used generally for heating purposes and in some isolated cases for drying various materials. Its application to mechanical refrigeration in power plant production has progressed to a certain stage. It has been generally recognized that such units as the lighting or trolley systems have excess loads in the morning and evening. Formerly this was taken care of by storage batteries, but their rapid deterioration and general cost of maintenance was such that it has been found preferable to operate a full size plant for the load at maximum. This is due partl. to the increased efficiency of large plants and to the necessity of a choice between two evils. This latter situation presented a large excess power available at slack time and this excess has in some cases been sold to small refrigeration consumers operating their own plants. Mechanical refrigeration possesses this further advantage in this field. It can be operated intermittently. Thus by the use of a large brine storage tank refrigeration can be produced in the brine and kept here for long periods of inactivity with small waste and utilized when wanted. Thus the power plant in its development has aided the development of a large number of small unit refrigerating systems by the furnishing of sufficient power at minimum cost at irregular intervals.

Further, owing to the ability of mechanical refrigeration to operate intermittently and in reality to take the place of the storage battery in the storage of energy, it has found a place in the modern plant. Thus many small trolley and lighting systems operate a refrigerating or cold storage plant as well. The excess current being turned into refrigeration when not needed and the cold brine carrying this system over the inactive period when power was needed along other lines. This has proved extremely efficient, and in many of the smaller cities such plants are in active operation.

The advent of the absorption system with its remarkable increase in efficiency threatens to produce a change in the present conditions. Modern power plants in large units require complicated prime movers using superheated steam and generally of the compound condensing type, whose cost of maintenance and high first cost is often almost prohibitory. The absorption system cannot use efficiently high pressure superheated steam. The compression plant itself is inefficient in the production of refrigeration. Hence, it, in turn, will be displaced for large units, and we shall have the rather anomalous condition of large refrigerating concerns with excess power for sale, using simply plain slide-valve engines of low efficiency and large steam consumption. Such a plant could sell power as a by-product in quantities and at prices such that the ordinary unit in this field could not compete. Further, the modern power plant has an additional by-product available in the utilization of its exhaust steam in the production of mechanical refrigeration. The interrelations between these two engineering developments are at their inception and time only can develop the exact situation. However, conditions are such at present as to point almost conclusively to a radical change in their interrelations and a complete innovation in the production of power.

LIFE AND WORK OF THE "SAND HOG"

"Excavating Skyscraper Foundations," by T. Kennard Thomson, in the *Engineering Magazine* for October, is an excellent article throughout. It is a clear, accurate and eminently readable account of the development and present status of this important line of work by an engineer who has contributed materially to the improvement of the means and methods employed. The following having to do with the men who work under pressure in the caissons requires no commendation from us.

Sand hogs work in eight-hour shifts—that is, three gangs in twenty-four hours, each gang taking half an hour for lunch and seven and one-half hours for actual work, for which they receive $3.50 a day, until the air pressure exceeds 20 pounds per square inch. As the pressure increases the pay increases, but the hours of labor decrease until at 45 pounds (in addition to atmospheric) the men only work one and one-half hours a day, and even that is divided into two shifts of three-quarters of an hour each and four hours apart; this is all the men can stand, and even then there is great danger of the bends, or worse, of being paralyzed. Many can not even stand the light pressure.

The first effect generally noticed when the air is let into the lock is the pressure of the air on the ear drums, and if this pressure is not quickly equalized, the ear drum is ruptured, of course, for life. At other times this plugged sensation results in blood vessels being ruptured in the head which danger is much greater if the person has a cold to start with. In fact, if one has a cold or anything wrong with his heart or lungs, he has no business to try to enter the lock at all. Even men in apparent perfect condition can not always stand it. A lock might be described as a small room with two doors like the vestibule of a house, so that if one enters and shuts the outside door before opening the inside door only the amount of air contained between the two doors is lost in passing in or out. It is necessary to have an air lock to prevent all the air escaping from the air chamber every time men or material pass through the lock, for if all the compressed air were allowed to escape from the working chamber, even for a very short time, the chamber would quickly fill up with mud and water, with probably disastrous results to the adjoining buildings, to say nothing of the loss of human life.

When the compressed air is allowed to enter the lock too quickly, and sometimes even when considerable time has been taken in entering and leaving the lock, it is supposed that the air bubbles force the blood away from the surface and then, when coming out of the compression, many of the bubbles remain in the system, which results in the "bends," a very painful experience. The attack is usually in the arm or legs. The longer one stays in compressed air and the more exertion taken in it, the greater the risk of the bends, which, however, often do not make themselves felt for several hours after coming out, although some claim that they can tell that they are getting the bends while still in the air chamber. The worst form of caisson disease is paralysis, from which some die at once, some recover, and others are afflicted for the rest of their lives; and which it will be none can tell. Many of the old watchmen seen on these jobs, humping around with a cane, are such victims.

A schoolgirl was once asked where could you walk the faster, on top of a high mountain, where the pressure is very much lighter than what we call atmospheric (nearly 15 pounds per square inch) or down in a caisson where one has to carry, say 20 to 40 pounds, on every square inch of the body in addition to the atmospheric. At first she thought on top of the mountain, but quickly corrected herself by saying: "Of course not, for more work could be done in the compressed air on account of the great supply of oxygen." The excess of oxygen not only gives the men great energy and appetites—you see seldom a thin sand hog—but it also makes candles, matches, cigars, etc., burn much faster; in fact, frequently, men have blown out a candle and put it in their pockets, only to find their coat on fire in a few minutes. One seldom sees an old sand hog; they must burn up their energies. It has often been a matter of comment that even the best of sand hogs are about useless if given an outside job; whether they lose their inclination or ability to do good work, I know not.

SOME PECULIARITIES OF IMPLOSION

Every one knows what an explosion is; but its opposite, an implosion, is less familiar. At great depths in the sea the conditions are favorable for its production. At twenty-five hundred fathoms the pressure is, roughly speaking, three and a half tons to the square inch; that is to say, fifty to a hundred times greater than the pressure exerted by the steam upon the piston of a powerful engine. An interesting experiment to illustrate the enormous force of this deep-sea pressure was not long ago made on the Albatross, a government vessel engaged in deep-sea exploration. A thick glass tube several inches in length full of air was hermetically sealed at both ends. This was wrapped in flannel and placed in one of the wide copper cylinders, used to protect deep-sea thermometers when they are sent down with the sounding apparatus. The copper cylinder had holes bored in it, so that the water had free access inside, around the glass. The case was then sent down to a depth of two thousand fathoms, and drawn up again. It was found that the cylinder was bulged and bent inward, just as if it had been crumpled inward by being violently squeezed. The glass tube itself, within its flannel wrapper, was reduced to a fine powder, almost like snow. The glass tube, it would seem, as it slowly descended, held out long against the pressure, but at last suddenly gave way, and was crushed by the violence of the action to a fine powder. This process, exactly the reverse of an explosion, is termed an implosion.

REFRIGERATION ON THE LUSITANIA

Two distinct and complete sets of refrigerating machinery are installed upon the Lusitania, one for the steamer's own provisions and another for use on any cargo which might require refrigerating. The provision chambers are situated on what is known as the lower deck, and are insulated with granulated cork and a special paper impervious to damp, with the necessary casing of white pine boards. These chambers have a total capacity of about 13,000 cu. ft., and are divided into compartments, each compartment for the storing of a separate provision. The refrigerating machinery for the provision chambers is located near the forward end of the main engine room, at the level of the main deck, uses CO_2 as the refrigerant, and is in duplicate. The two compressors are placed horizontally, and work from a main shaft, which is driven direct by an electric motor. The cargo cold storage comprises six large rooms on the orlop deck forward, insulated with granulated cork and damp-proof paper, with a casing of white pine boards, and cooled by the circulation of cold brine. The chambers have been fully provided with conveniences for stowing different kinds of goods likely to be carried. The machinery for cooling this cargo space is located on the shelter deck at the starboard side forward, and is also in duplicate, and driven by an electric motor. A notable feature of the machine installations is that each one is placed in an insulated room, so as to be accessible without any lagging or insulation having to be removed.

THE WINDMILL AND THE STORAGE BATTERY

Although, for any purpose requiring a more or less continuous supply of power, the wind is a wholly unsuitable source of energy, there are, nevertheless, many cases in which it can be utilized with advantage. Even if it has to be supplemented by a stand-by such as an oil engine, and worked in conjunction with a storage battery (which is generally an indispensable adjunct), wind-power may prove a source of economy. A few results derived from a series of experiments which has been carried on for some years by the Danish Government may, therefore, be of interest.

The velocities of the wind which are practically utilized lie between 10 and 50 feet per second, and the motor must be so constructed as to adapt itself automatically to all conditions, including storms. It has been found that a motor with only four wings is the best, and that if the surface of the wings in square feet is S, the velocity of the wind V in feet per second, and the output in horsepower is W, then $W = S V^3 \div 456,000$. Thus, for a surface of 100 square feet, with velocities of 10, 20, 30 and 40 feet per second, the power available is 0.22, 1.8, 6 and 14 horsepower respectively. At the experimental station of Askow, with a petrol-motor as standy-by and a storage battery, an installation of 450 incandescent lamps has been successfully run for two years, at a fair profit, even after allowing for interest and sinking fund charges on a 25-year basis.

COMPRESSED AIR ON THE BELMONT TUNNEL WORK

The various tunnel and subway undertakings, which are to so vastly increase the transit facilities of Greater New York, are quite different from each other in the conditions and means of construction, and each has imposed special engineering problems to be solved. Not the least interesting was the work on the Belmont tunnel, now completed and likely to be the first in actual and established service.

This tunnel and subway is over three miles long, extending from Park avenue and Forty-second street, Manhattan, to Jackson avenue and Fourth street, Long Island City, and will afford easy and quick transit between the boroughs of Queens and Manhattan, connecting with the Interborough system of subways near the Grand Central station. The first shift was started in July, 1905, and work has been rushed continuously and with tremendous vigor night and day until its recent completion. This tunnel consists of two tubes running parallel, each for a single track. Part of the tubes are horseshoe shaped, while under the river they are circular and built of sectional cast-iron rings. The builders of this tunnel, The Degnon Engineering and Construction Company, had an advantage as to time of construction, in that their tunnels could be driven from four headings instead of two, or, in the case of the Cortlandt street tunnel, from a single heading.

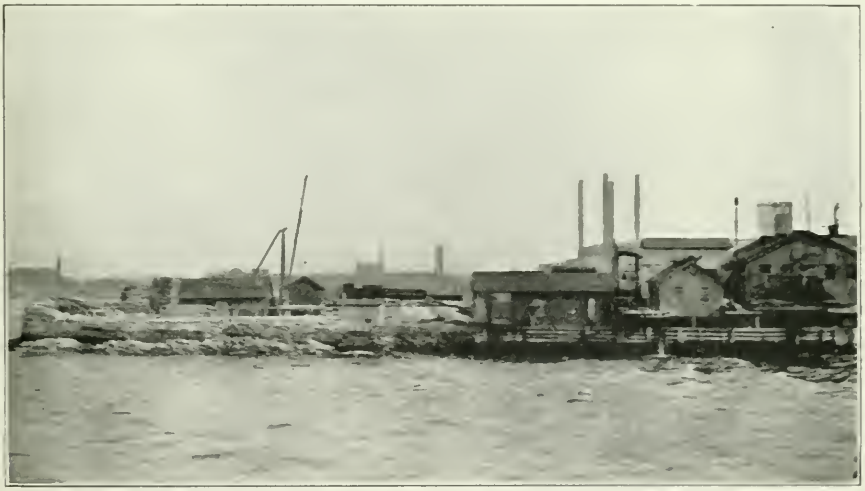

FIG. I. WORKS ON MAN-O'-WAR'S REEF.

FORTY-SECOND STREET AND EAST RIVER PLANT.

For driving the tunnel from its western end and for the subway westward through Forty-second street there were two separate installations, resulting from certain business arrangements. The plant of the O'Rourke Engineering Company, sold to the Degnon Company, comprised: one Rand cross compound Corliss two-stage air compressor with steam cylinders 24 and 40 by 48 inch stroke and air cylinders 39 and 24 inch; free air capacity, 4,147 cu. ft. per min., and one Ingersoll cross compound Corliss two-stage compressor, with steam cylinders 22 and 40 by 42 inch stroke, and air cylinders 38 and 24 inch; free air capacity, 3,937 cu. ft. per min.

The Degnon Contracting Company's own plant at the same point comprised three Ingersoll cross compound steam, duplex air, class "H" compressors, with steam cylinders 15 and 28 by 16 inch stroke, and air cylinders 20¼ inch diameter, for a maximum air pressure of 50 lbs.; free air capacity, 6,540 cu. ft. per min. There was also one Ingersoll cross compound steam, two-stage air, class HC compressor, with steam cylinders and stroke the same as above, but with air cylinders 25¼ and 16¼ inch diameter for 100 pounds air pressure; free air capacity, 1,704 cu. ft. per min.

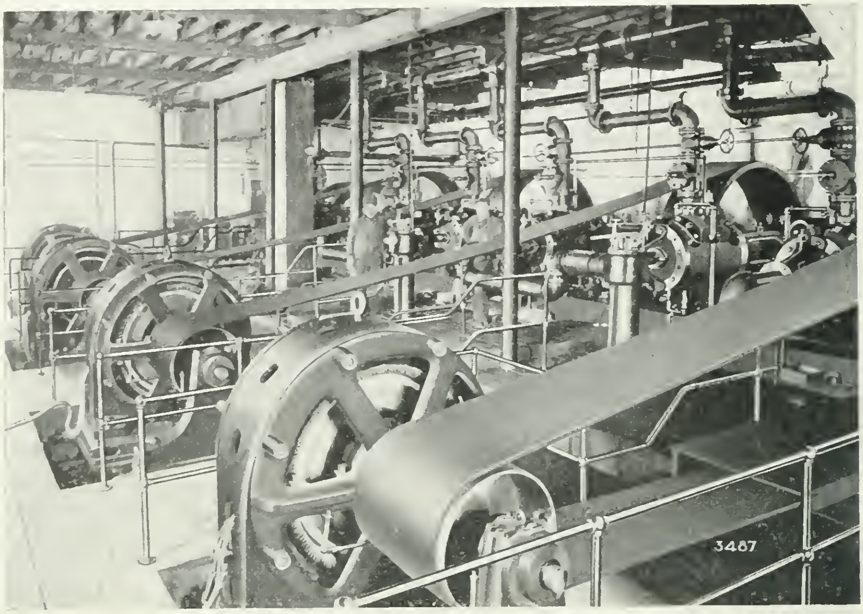

FIG. 2. ELECTRIC DRIVEN AIR COMPRESSOR, MAN-O-WAR'S REEF.

MAN-O'-WAR'S REEF PLANT.

The most interesting, in some respects, of all the New York tunnel plants was that installed by the Degnon Contracting Company upon Man-o'-War's Reef in the middle of the East River, opposite Forty-second street. The existence of this reef suggested the sinking of two shafts there, giving four additional working faces for the two tunnels. The first thing to be done was to get standing room, as the original area was entirely insufficient. At first a single straight line Ingersoll compressor, with a portable boiler, was placed, and the sinking of the two shafts was begun, the material from the shafts being used for filling upon and around the reef until a sufficient working area was secured. The complete plant as finally installed had not a foot of space to spare. Fig. 1 is a snapshot of the exterior of the plant taken from a passing boat. The compressor room, the interior of which is shown in Fig. 2, extends to the water's edge on two sides, with only a small space on the New York side, while to the north enough land was made to provide for the moving of dirt cars to scows on either side.

The compressors used here comprised: first, one Ingersoll-Sergeant straight line, class "A," 24 inch diameter steam and 26¼ inch diameter air by 30 inch stroke; free air capacity, 1,843 cu. ft. per min. This is the most distant compressor in the half-tone, Fig. 2, which chiefly shows the four electric driven machines. Three of these were duplex, class "J," Ingersoll, belted compressors, with air cylinders 20¼ inch diameter by 16 inch stroke; aggregate free air capacity, 6,540 cu. ft. per min. The fourth electric driven machine was a two-stage compressor with air cylinders 25¼ and 16¼ inch diameter by 16 inch stroke; free air capacity, 1,704 cu. ft. per min., this compressor delivering the air at 100 lbs., while the maximum pressure for the other three was 50 lbs.

These compressors were all run at constant speed, the air delivery being regulated by choking controllers on the intake. There was another straight line, steam driven compressor at the eastern end of the line and not included in the half-tone. The current for the electric drive was taken from a cable connecting with the Manhattan lines of the Interborough Company. The elevators in the two shafts also were electric driven from the same source. Locomotive boilers supplied the steam required for the straight line machines, the feed water being piped from Manhattan.

While this plant, on account of its location and its forbidding accompanying conditions, might have been regarded as more or less an emergency plant, it must not be thought to have been necessarily or actually a wasteful one. The electrically driven machines in this case, taking their current from a service in which the highest possible economies are attained, and having motors adapted to their work, delivered the air at a lower cost than that of the straight line, steam driven machines, notwithstanding that the latter represent still widely prevalent practice.

LONG ISLAND CITY PLANT.

Fig. 3 shows the interior of the power house of this plant. There were in service here two Ingersoll cross compound steam, two-stage air, class "H" compressors, with steam cylinders 15 and 28 by 16 inch stroke, and air cylinders 25¼ and 16¼, designed for 100 pounds air pressure; free air capacity, 3,408 cu. ft. per min. There were also two Ingersoll class "A" straight line compressors, 24 and 26¼ by 30 inch stroke; free air capacity, 3,686 cu. ft. per min., and one Ingersoll class "A" compressor, 24 and 24¼ by 30 inch stroke; free air capacity, 1,570 cu. ft. per min. These three compressors were for low-pressure air. Heine boilers were used.

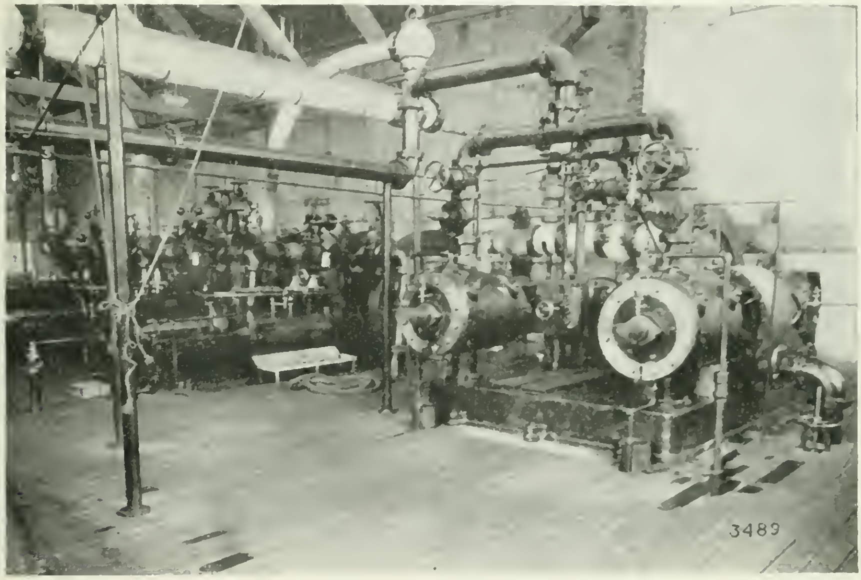

FIG. 3. AIR COMPRESSOR, LONG ISLAND CITY.

PUMPING ARRANGEMENTS.

While the pneumatic pressure maintained in the tunnels until completion was always equal to or somewhat in excess of the hydrostatic pressure due to the submergence, there was a constant accumulation in the machines and workings of water, which was taken care of by air operated pumps. While the air pressure would be in excess at the top of the shield it might still be insufficient at the bottom and here the water would work in. This water was collected in temporary sumps in the air locks, and from there was forced out by the air pressure through the pipes to the various pumping stations situated along the line of construction. There was also a constant seeping through the joints where the calking had not been completed, the sumps for this water being situated where the grade was the lowest and where the pumps were located, pumping the water to the surface or directly into the river, or, for the land sections of the tunnels, into sewers connecting with the river.

In several places the segments or wall plates were removed and the rock or other material forming the 8-foot partition between the two tubes was cut away, to provide sump chambers (see Fig. 4), and allowing room for the pumps. Where the pumps were situated alongside the tunnel walls and in the workings, no extra room was required for their installation (see Fig. 5), as these pumps were all of the Cameron type, with their well-known characteristics and lack of protuberant parts. These pumps have no outside valve gear, and moving levers to be deranged or broken are entirely absent. They were reliable in cases of sudden flooding and would work just as well when submerged to any depth. In cases of accident or emergency they could also be run up to double their normal capacity.

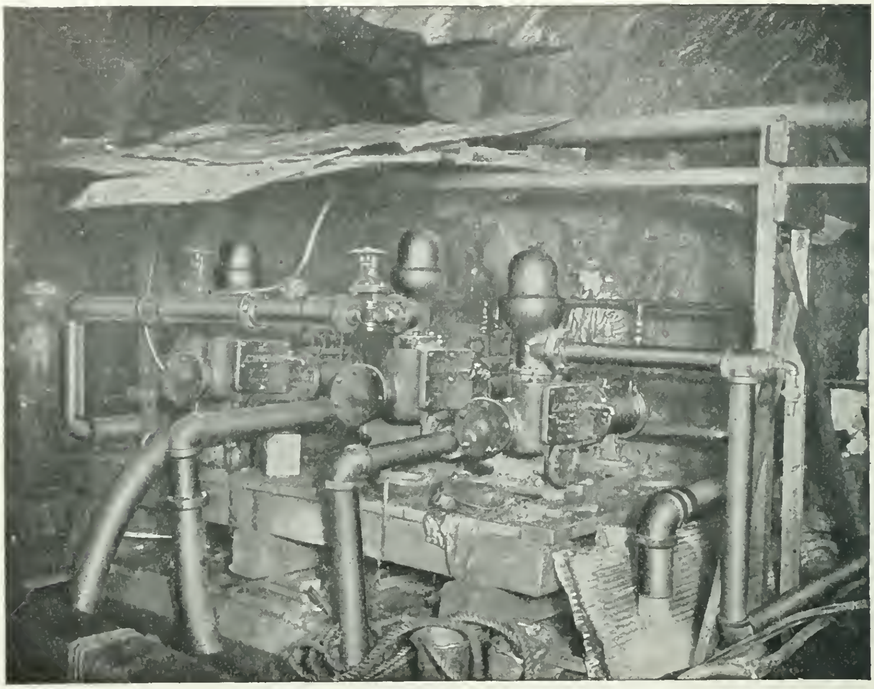

FIG. 4. PUMPS IN CHAMBER BETWEEN TUNNELS.

A unique and simple device was attached to the pumps to keep the exhaust compressed air from freezing and choking the passages. A small pipe was connected from the water discharge pipe to the exhaust openings of the air operated cylinder, and through it a ⅜-inch nozzle discharged constantly when the pump was running. This not only prevented freezing, but also had the effect of a muffler on the exhaust, which otherwise would have been deafening to the workers. These pumps, as was stated, were driven by compressed air, as were also the drills and the hoisting and other machinery employed.

EXPERIENCE WITH HIGH PRESSURE GAS MAINS*

By Sherwood Grover.

High pressure gas distribution, although not very old as applied to artificial gas, is no longer an experiment. When we say high pressure we mean over two pounds per square inch. There is a point beyond which, under given conditions of cost for power, materials, labor, etc., it will not pay to raise the pressure, but instead it is time to increase the diameter of the pipe, or in case of a system already installed, to lay another pipe.

High pressure systems are of two kinds. One type in which the high pressure mains are simply feeders in the form of arteries running through a district, with regulators connected here and there to boost up pressure at weak points in the low pressure distributing mains, or they may be in the form of a loop entirely circling a town and feeding in at the dead ends. The other type is where the entire system is high pressure, varying in degree, with regulators reducing the feeding main pressure of 20 pounds or more to a distributing main pressure of 2 to 5 pounds, and this in turn reduced by regulators on each house service. The writer does not favor the second type of installation, although there are conditions under which it works very well, preferring rather low pressure on all distributing mains, not to exceed 12-inch water column, with no high pressure on service pipes. This method allows using a small and practically uniform size of pipe for distribution mains in given districts, and is specially adapted to suburban tracts, where consumers are wide apart, and main extensions do not pay high returns un investment. It is surprising how many consumers with gas bills ranging from $10 to $25 per month can be supplied by a 2-inch pipe carrying a pressure of 10-inch water column.

A high pressure system can be for convenience considered as consisting of three dif-

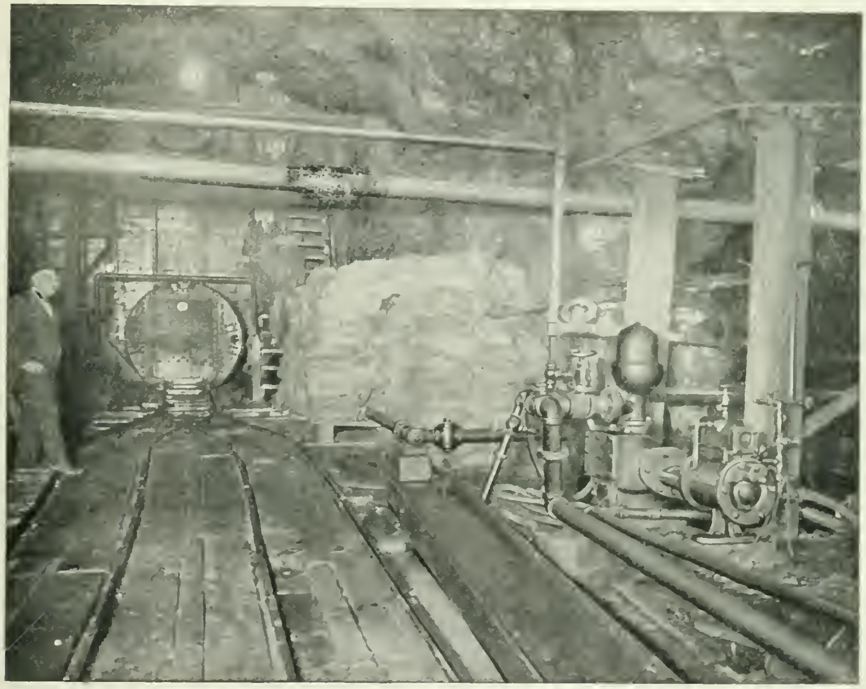

FIG. 5. PUMPS IN TUNNEL WORKINGS.

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*Condensed from The Journal of Electricity, Power and Gas.

ferent parts, namely, the compression plant, the storage plant and the feeding mains.

THE COMPRESSOR PLANT.

This includes the compressors, their motive power and piping system. There is considerable opportunity for difference of opinion as to motive power, type and size of units employed, and arrangement. In case electricity is used, it is necessary to have either gas engine or steam engine auxiliary to insure against interrupted service, or else the storage plant must be of sufficient capacity to bridge over any delay which may occur.

The most efficient compressors should be used, but there are several little points, such as unloading devices, automatic or otherwise, which have more or less merit, depending on the size of the installation. An automatic unloader is very handy in a small installation, but the writer questions the economy of it in a large installation. All automatic unloaders are virtually by-passes, and by-passing compressed gas means excessive temperature of the compressor, and of the gas being compressed. Unloaders of the pattern used on compressors with Corliss valves, by which the machine can be operated at one-quarter, one-half, three-quarters or full load, are very useful. They must, however, be used with judgment, and wear on the compressor be equalized by changing sides when running at part load, so that each part of the machine has the same total number hours work.

The size of units, of course, depends upon the peak load, unless you are depending on the storage plant to carry you over. Our experience in California has, however, taught us that a unit approximately equal in capacity to the peak hourly sent out is none too large, and as it is, of course, necessary to have duplicate apparatus, it is well to have the units of varying capacity, so that by running different units during the day it can be so arranged that they are running at full load, and hence at best economy, most of the time.

STORAGE PLANT.

This consists of a battery of compression tanks, arranged on a suitable foundation, together with the system of piping and regulators connecting them to the distributing mains.

A standard size and type of tank has been adopted by our company, which was determined by economy and ease of handling and railroad transportation, together with least cost per cubic feet stored. This size is six feet in diameter by thirty feet in length, with dished heads. It has one manhole fitted with cover and yoke, one 2-inch reinforced tapped hole, which serves as both inlet and outlet, and one 1-inch reinforced tapped hole, to be used for drip pipe.

These tanks are placed in a row on the foundation, the number depending upon the amount of ground which can be used to best advantage. Other rows may from time to time be added on top of the first, making this installation a flexible one, which can be increased each year at a comparatively small cost, to meet the demands of a growing town. One tank, which we call the low pressure tank, differs from the rest in that it is a distributing tank and not a storage tank, and although it is equipped with a manhole and drip connection, like the storage tanks, it also has extra connections, to which are attached the regulators supplying the different feeding mains of the town.

In large installations it has been found most satisfactory to carry 20 pounds or under on the feeding mains, and hence the main compression units are built for this pressure only. As it is necessary to use 100 pounds pressure (not less than 80 pounds) on our storage tanks, in order to get capacity, it, therefore, follows we must have a compressor capable of compressing to 100 pounds. This unit, on account of the nature of its work, can have a very small capacity in comparison to the other machines of the installation, its use being simply to keep the storage tanks full.

The general arrangement of the compression and storage plant is as follows: The discharge from the 20-pound compressors is carried by a single line of pipe to the 20-pound tank, a branch being taken for suction to the small 100-pound compressor, so that it may take gas either at 20 pounds, or at holder pressure, as the case may be. The discharge from the 100-pound compressor is carried by a single line of pipe to the storage tanks, a 2-inch connection with valve being made to each tank. This same header is continued to the 20-pound tank and is connected to it through a regulator and by-pass. This regulator is set to maintain a pressure less than 20 pounds, say, for example, 15 pounds, then as long as there is 20 pounds pressure on the distributing tank, this regulator is shut; but if for any reason the pressure drops, then this regulator comes into action and maintains the pressure at 15 pounds, as long as there is anything in excess of this in the storage tanks, or the small compressor is able to keep it up. The various feeding mains of the city are taken directly from the 20-pound tank, with a separate regulator on each, so that any pressure under 20 pounds can be carried on any main independent of the others.

In installing a complete plant of this nature, there are many practical points to which attention must be given to avoid trouble. To begin with, the compression tanks must be handled with care, to avoid subjecting them to unequal strains, which may cause the seams to leak.

After considerable experience with valves it has been found that nothing but extra heavy ammonia valves can be relied upon, and even these at times give trouble. An hydraulic test on a valve or stop cock is absolutely worthless if the fitting is to be used for high pressure gas.

A high pressure feeding main is subject to some of the physical laws which govern the design of a blast pipe supplying a number of sets of water gas apparatus; at the same time it is under some of the physical laws governing steam pipe design.

It naturally follows that all sharp turns should be avoided, using instead, easy curves and long sweeps. It is even well to substitute **Y** fittings in place of crosses or tees, where branches are taken from the main feeders.

In laying the line, care must be taken to properly anchor and brace all curves or bends. The gyrations of a garden hose, if left to itself with a good head of water on it, will serve to illustrate what will happen if this precaution is neglected.

The regulators are placed in manholes built in the street. They are either brick or concrete, and each regulator has an inlet and outlet and a by-pass valve. The use of two regulators in parallel is advocated, and, I believe, in use in some locations. We have found in this climate that one extra regulator of each size on hand is a good plan. As the regulators are inspected at regular intervals, trouble can be anticipated and the regulator removed to the repair shop, where proper adjustment can be made while the extra one takes its place. During the change the by-pass is operated.

The matter of drips has caused considerable trouble, but principally in systems where the entire installation is high pressure, or where the feeders are small. A device composed of fittings has been used in some cases, which makes the gas turn at a sharp angle to precipitate its moisture. This works very well on high pressure distribution mains of small installations, but it is not practical in a feeder at all. At first it was deemed sufficient to merely tap the main and blow out the condensation, with its own pressure. Experience, however, has shown that this does not always give satisfaction, and it was found necessary to go back to the low pressure gas practice and design a drip pot with an opening the full size of the pipe, which can be inserted in the line by means of flange-coupling adapting pieces. If you stop to consider that there is a time of minimum consumption during the twenty-four hours, when the gas in the mains is almost at rest, the velocity being practically nothing, and that this occurs when the temperature is lowest, and hence best for precipitation of moisture, it is apparent that if these drip pots are placed at the low points they will catch the condensation; then it is an easy matter to blow it out with pressure.

COMPRESSED AIR IN BLAST FURNACES

The most voluminous use of compressed air in any single industry is in the blast furnace. Prof. Bradley Stoughton of Columbia University in a description of a typical American blast furnace says:

The air for smelting is driven into the furnace by blowing engines up to 2,500 horsepower each, and capable of compressing 50,000 to 65,000 cubic feet (4,875 pounds) of free air per minute to a pressure of 15 to 30 pounds per square inch, which is about what one furnace requires. It actually requires about four to five tons of air for each ton of iron produced in the furnace. After leaving the engines and before coming to the furnace the air is heated to a temperature of 800 to 1,200° F. by being made to pass through the hot-blast stoves.

[The horsepower mentioned would be only sufficient for the compression of the smaller volume to the lower pressure. For compressing the larger volume to the higher pressure double the above horsepower would be required. Ed. C. A.]

CLEANING STEELWORK BY SAND BLAST AND PAINTING BY COMPRESSED AIR

By De Witt C. Webb.

At the U. S. Naval Station, Key West, Fla., are two large steel coal sheds whose vertical side walls are composed of ¼-inch steel plates, and are from 16 to 20 feet high. The action of heat and impurities in the coal, combined with that of the large quantities of salt water used for extinguishing spontaneous combustion fires, rapidly corrodes the interior steelwork and necessitates its thorough cleaning and painting every time the sheds are emptied.

Shortly after the writer was detailed to this station his attention was attracted to this subject, and he concluded that the use of a portable sand blast cleaning and spray painting outfit would be very advantageous in point of efficiency and time as well as cost. This idea meeting with the approval of the Bureau of Yards and Docks, the following outfit was purchased at a cost of $2,090, delivered at the Naval Station:

1 horizontal gasoline engine, about 20 hp.
1 air compressor, capacity about 90 ft. of free air per min. compressed to a pressure of 30 lbs. per sq. in. in one stage, belt connected to engine.
1 rotary circulating pump, belt connected to engine.
1 Galvanized steel water tank.
1 air receiver, 18 × 54 ins.

(The above apparatus was all mounted on a steel framed wagon with wooden housing.)

2 sand blast machines, capacity 2 cu. ft. of sand each.
2 paint spraying machines, one a hand machine of ⅔-gal. capacity for one operator, the other of 10 gals. capacity for two operators.
100 lin. ft. of sand blast hose.
200 lin. ft. of pneumatic hose for sand blast machines.
400 lin. ft. of pneumatic hose for painting machines.
100 lin. ft. of air and paint hose for painting machines.
4 khaki helmets, with mica-covered openings for the eyes.
200 lin. ft. of 2-in. galvanized iron pipe.

Previously to the delivery of this material, shed "A" had been emptied of coal and the work of cleaning the inside surface of the wall plates was begun by hand in the usual manner. About 7,000 square feet out of a total of 9,000 were thus cleaned at a cost of slightly over 4 cents per square foot. On the arrival of the sand blast outfit the hand work was stopped and after a short preliminary trial the machine cleaning was started. The work proceeded rather slowly until the men became accustomed to it, yet the 2,000 square feet of previously untouched surface was thoroughly cleaned and the 7,000 square feet of hand cleaning was all gone over and much improved at a total cost for labor of $97.68 and for gasoline of $16.15. The force consisted of the following:

	Per day.
1 engine tender	$3.04
1 helper (in charge of the work and tending machines)	2.24
2 laborers on machines, at $1.76 each	3.52
1 laborer drying sand, filling machines, etc.	1.76
Total	$10.56

From 10 to 15 gallons of gasoline were required per day of 8 hours (costing 19 cents per gallon here).

For the painting the coal tar paint originated by Civil Engineer A. C. Cunningham, U. S. N., was used (see *Eng. News,* July 12, 1906). This paint was prepared with the following proportions (by volume): Coal tar, 4 parts; kerosene oil, 1; Portland cement, 1.

The Portland cement was first well stirred into the kerosene oil, forming a creamy mixture; this mixture was then carefully stirred into the coal tar. It was freshly mixed as needed and kept well stirred. The cost of this paint at Key West is about 15 cents per gallon. It was found not to be so well suited to the pneumatic spraying machine as oil paint, but worked very well; though, of course, the machine used considerably more than hand work. In all, on this shed, 64½ gallons of paint were required for 9,000 square feet, or about 1 gallon to 140 square feet. The force used in painting was the same as in cleaning, with the addition of a laborer, who followed up the painters with a long-handled brush and spread the paint uniformly. The cost of painting this shed was: For labor, $28.16; for gasoline, $3.80.

On shed "B" a total area of 12,500 square feet was cleaned and painted. This steelwork was covered with a scale nearly ⅛-inch thick and was deeply pitted. The scale and rust was very tough, and extremely hard to remove. On this work it was found economical to keep men ahead of the sand blast with sledges, loosening and shaking off as much of the scale as possible. The labor cost of the whole work on this shed (cleaning and painting) was $460, including the cost of moving, setting up and removing. Gasoline cost $81. A total of 86 gallons of coal tar paint was used, covering about 145 square feet per gallon. Total cost of labor, fuel and paint, $553.90, or 4.4 cents per square foot. It is impossible to separate the cost of cleaning and painting on this work, as only small areas were painted at one time, the painting being done by one operator, the other working the sand blast. This was done in order to expose the cleaned steel to the atmosphere for as short a time as possible.

A fine silica sand was used, that being the only kind available except coral sand, which was tried, but found to be too soft. A coarser sand would probably have been more effective. The sand was all saved, dried, and re-used several times. About ½ cubic yard of fresh sand was required daily. The sand must be kept perfectly dry for this purpose, and there are patented sand driers manufactured. Very good results were obtained on this work, however, by the use of a sheet of boiler plate set up on bricks with a wood fire underneath.

No claims are made of extreme economy in the above work. The extremely thick and tough scale to be removed, the high fuel and labor cost of compressing air simply for this work, and (probably) the lack of the best kind of sand for the purpose, combined to make the work expensive. With these drawbacks it was, however, considerably cheaper than hand work, and what is more important, the cleaning was much more effective and thorough than could possibly have been done by hand.—*Engineering News.*

COMPRESSED AIR DISTRIBUTION

A correspondent writes to *South African Mines*, Johannesburg, as follows:

"It is obvious that no matter what the air pressure is at the compressor house, or at the different stations in the Rand mines, the last machine, or the last few machines, taking air from the air pipe on any level must receive less pressure than those near the air column in the shaft. To explain: The first machine to receive air from the connection at each station will, obviously, obtain the greatest pressure, the second a little less, the third less still, and so on; the fourteenth or fifteenth is always badly served. From reference, I can tell you that, in most instances, the first machine has far too great a pressure, and often one dare not turn on the full force, but must work at three-quarter. This is regulated by the machine tap. While at the other end, say the fifteenth machine, it would be good work to drill two 6-in. holes in eight hours. My suggestion is that the 3-in. or 4-in. pipes in the level be tapped near the center of the working area, and a pipe run *back* towards the main connection. Then the air pressure would be evenly distributed, and as development proceeds the tapping of the main could be changed from time to time."

This seems to suggest a state of affairs entirely unknown in American practice and which might be thought to be impossible even in South Africa. Unless the pipe line was extremely small and the distances great, with all the drills working constantly, no such experience as above indicated could occur. In American mining practice every drill on the line gets very nearly the same pressure, and if this pressure is sufficient for the first it should not be very deficient for the last, while if the pressure was not sufficient all the drills would suffer. The impression is that insufficient compressor capacity is the familiar condition in South Africa, and that few drills there have sufficient air in both pressure and volume.

STEAM CONSUMPTION IN AIR COMPRESSORS

The accompanying tables have been prepared by Mr. O. S. Shantz, M. E., Detroit, Mich., and are an entirely new and important contribution to engineering data. They show the weight of steam required to compress 100 cubic feet of free air to the various gage pressures listed either in single or in two-stage compression. They are based on the various steam consumptions per indicated horsepower per hour shown at the head of each column. The computations are based on adiabatic compression in all the cylinders with a mechanical efficiency in the compressor of 90 per cent.

The mode of using these tables will be as

Pounds Steam Consumption per I. H. P. per hour......	12	12½	13	13½	14	14½	15	15½	16	16½	17	17½	18	18½	19	19½	20	20½	21	21½	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Air Pressure, Gauge 20	1.36	1.42	1.47	1.53	1.58	1.65	1.70	1.75	1.82	1.87	1.92	1.98	2.04	2.09	2.15	2.21	2.26	2.32	2.38	2.44	2.49	2.60	2.72	2.83	2.94	3.06	3.17	3.28	3.40	3.50	3.61	3.74	3.85	3.97	4.08	4.18	4.30	4.42	4.54
" " 30	1.84	1.92	1.99	2.07	2.14	2.23	2.30	2.37	2.45	2.53	2.60	2.68	2.76	2.83	2.92	2.99	3.06	3.14	3.22	3.30	3.37	3.52	3.68	3.82	3.98	4.14	4.29	4.44	4.60	4.75	4.90	5.06	5.20	5.36	5.51	5.66	5.81	5.97	6.12
" " 40	2.26	2.36	2.45	2.54	2.64	2.73	2.83	2.92	3.02	3.11	3.20	3.30	3.39	3.48	3.58	3.68	3.77	3.87	3.96	4.06	4.15	4.34	4.52	4.70	4.90	5.08	5.26	5.46	5.65	5.85	6.03	6.22	6.40	6.60	6.78	6.95	7.14	7.35	7.50
" " 50	2.62	2.74	2.84	2.95	3.06	3.17	3.28	3.38	3.50	3.61	3.71	3.82	3.93	4.04	4.16	4.26	4.36	4.49	4.59	4.71	4.80	5.02	5.25	5.45	5.68	5.90	6.10	6.33	6.55	6.76	7.00	7.20	7.42	7.65	8.86	8.05	8.27	8.51	8.71
" " 60	2.92	3.05	3.17	3.29	3.41	3.54	3.66	3.77	3.90	4.02	4.14	4.26	4.38	4.50	4.64	4.75	4.85	5.00	5.11	5.25	5.36	5.60	5.85	6.08	6.32	6.56	6.80	7.05	7.30	7.55	7.80	8.03	8.27	8.52	8.76	8.99	9.22	9.50	9.71
" " 70	3.22	3.36	3.50	3.63	3.76	3.90	4.02	4.16	4.30	4.43	4.56	4.70	4.83	4.96	5.11	5.24	5.36	5.50	5.64	5.78	5.90	6.16	6.45	6.70	6.97	7.25	7.50	7.77	8.05	8.32	8.60	8.85	9.12	9.40	9.66	9.91	10.16	10.45	10.70
" " 80	3.50	3.65	3.80	3.94	4.08	4.24	4.37	4.52	4.67	4.81	4.96	5.11	5.25	5.40	5.55	5.69	5.84	5.99	6.12	6.29	6.42	6.70	7.00	7.29	7.59	7.86	8.15	8.48	8.75	9.05	9.34	9.67	9.92	10.20	10.50	10.75	11.05	11.36	11.61
" " 90	3.72	3.88	4.06	4.19	4.34	4.50	4.65	4.80	4.96	5.11	5.26	5.43	5.58	5.73	5.90	6.05	6.20	6.36	6.50	6.68	6.82	7.14	7.45	7.75	8.05	8.30	8.66	8.98	9.30	9.60	9.94	10.21	10.54	10.85	11.15	11.41	11.74	12.09	12.35
" " 100	3.96	4.13	4.30	4.46	4.61	4.79	4.95	5.11	5.29	5.45	5.61	5.78	5.95	6.10	6.28	6.45	6.60	6.77	6.93	7.10	7.25	7.59	7.92	8.25	8.58	8.90	9.22	9.57	9.90	10.20	10.56	10.90	11.20	11.55	11.88	12.16	12.50	12.85	13.15
" " 110	4.18	4.36	4.54	4.71	4.87	5.06	5.22	5.40	5.58	5.75	5.92	6.10	6.26	6.45	6.63	6.80	6.96	7.15	7.31	7.50	7.66	8.00	8.36	8.70	9.05	9.40	9.75	10.10	10.45	10.76	11.15	11.50	11.84	12.20	12.52	12.84	13.20	13.55	13.90
" " 120	4.38	4.57	4.75	4.91	5.11	5.30	5.47	5.65	5.85	6.03	6.20	6.40	6.57	6.75	6.95	7.12	7.30	7.50	7.67	7.86	8.04	8.40	8.76	9.11	9.50	9.85	10.20	10.58	10.95	11.30	11.66	12.05	12.46	12.76	13.13	13.45	13.82	14.21	14.55

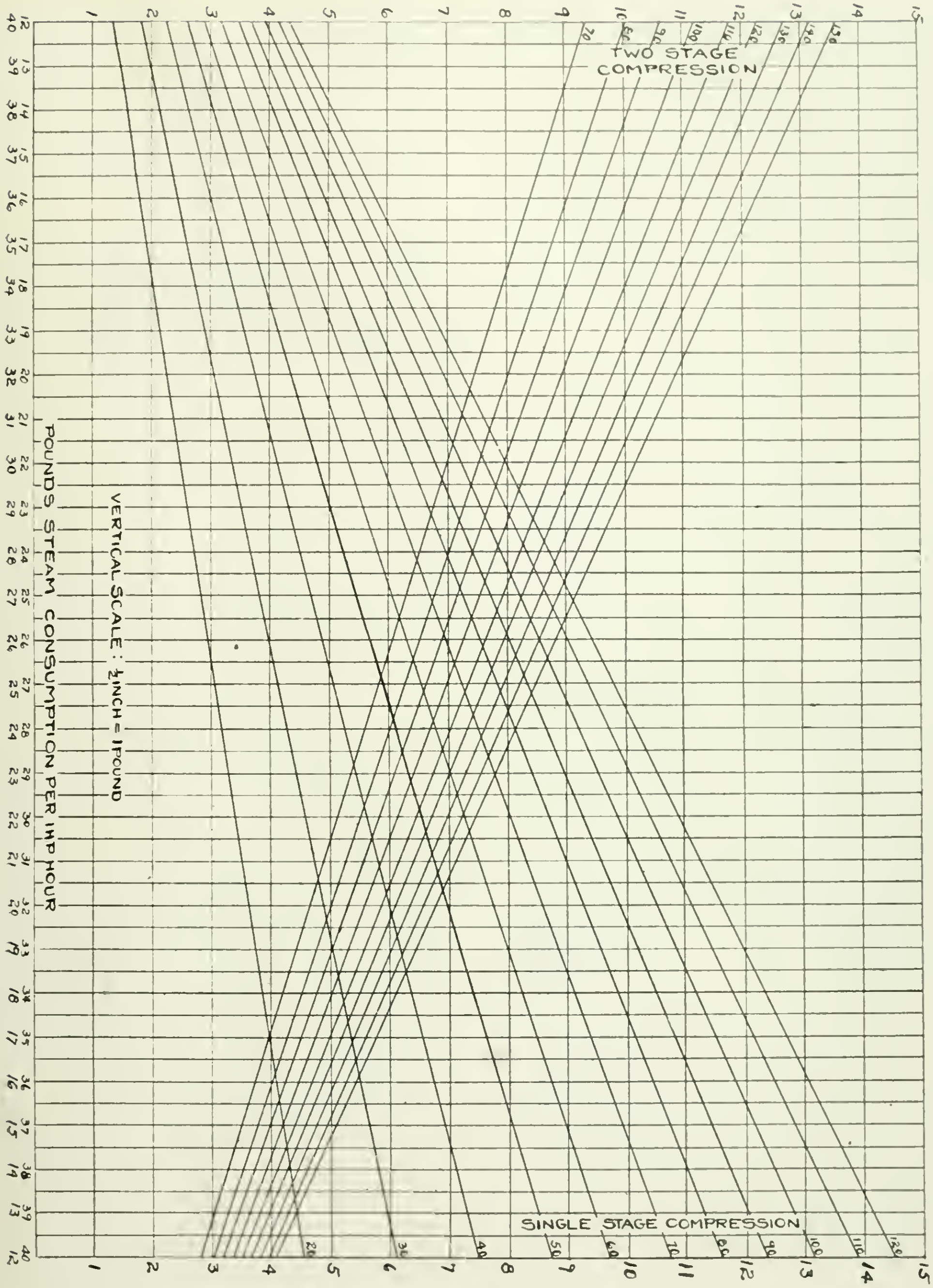
STEAM CONSUMPTION OF AIR COMPRESSORS.

SINGLE STAGE COMPRESSION.

Pounds Steam Consumption per I. H. P. per hour..........	12	12½	13	13½	14	14½	15	15½	16	16½	17	17½	18	18½	19	19½	20	20½	21	21½	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Air Pressure, Gauge 70	2.82	2.93	3.06	3.17	3.25	3.41	3.52	3.63	3.76	3.87	3.78	4.11	4.23	4.34	4.46	4.58	4.69	4.81	4.93	5.05	5.16	5.39	5.63	5.85	6.10	6.33	6.56	6.80	7.04	7.26	7.50	7.71	7.96	8.20	8.45	8.65	8.90	9.15	9.35
" " 80	3.01	3.13	3.27	3.39	3.51	3.64	3.77	3.89	4.03	4.15	4.26	4.40	4.52	4.64	4.78	4.90	5.02	5.15	5.27	5.41	5.53	5.77	6.03	6.27	6.53	6.78	7.03	7.27	7.53	7.78	8.03	8.29	8.53	8.78	9.05	9.25	9.53	9.86	10.01
" " 90	3.19	3.33	3.46	3.58	3.72	3.86	3.99	4.12	4.26	4.39	4.52	4.66	4.79	4.91	5.06	5.18	5.32	5.46	5.58	5.73	5.85	6.10	6.38	6.65	6.91	7.17	7.44	7.70	7.98	8.21	8.50	8.77	9.03	9.31	9.57	9.81	10.05	10.35	10.60
" " 100	3.37	3.51	3.65	3.79	3.93	4.07	4.21	4.35	4.50	4.63	4.77	4.92	5.05	5.18	5.34	5.47	5.61	5.76	5.90	6.05	6.19	6.45	6.74	7.01	7.30	7.57	7.85	8.15	8.42	8.70	8.99	9.26	9.55	9.85	10.10	10.35	10.63	10.95	11.20
" " 110	3.54	3.70	3.84	3.95	4.14	4.29	4.43	4.57	4.74	4.88	5.02	5.17	5.32	5.46	5.63	5.76	5.91	6.06	6.21	6.37	6.51	6.80	7.10	7.40	7.70	7.96	8.27	8.58	8.86	9.16	9.46	9.75	10.05	10.35	10.64	10.90	11.20	11.51	11.80
" " 120	3.69	3.85	4.00	4.15	4.30	4.46	4.62	4.76	4.93	5.08	5.22	5.39	5.54	5.69	5.86	6.00	6.15	6.32	6.46	6.64	6.78	7.08	7.38	7.69	8.00	8.31	8.61	8.92	9.24	9.53	9.85	10.15	10.46	10.75	11.05	11.35	11.65	12.00	12.27
" " 130	3.83	3.99	4.15	4.30	4.46	4.63	4.79	4.95	5.11	5.26	5.42	5.59	5.75	5.90	6.07	6.22	6.38	6.55	6.70	6.88	7.03	7.34	7.66	7.97	8.30	9.61	8.92	9.25	9.57	9.90	10.20	10.52	10.84	11.15	11.48	11.76	12.10	12.42	12.72
" " 140	3.96	4.13	4.30	4.45	4.62	4.79	4.95	5.11	5.29	5.45	5.60	5.79	5.94	6.10	6.28	6.45	6.60	6.77	6.93	7.11	7.26	7.59	7.92	8.25	8.60	8.90	9.23	9.56	9.90	10.20	10.56	10.90	11.21	11.55	11.88	12.18	12.50	12.85	13.15
" " 150	4.10	4.26	4.45	4.60	4.76	4.95	5.11	4.28	5.46	5.62	5.80	5.98	5.14	6.30	6.49	6.65	6.81	7.00	7.16	7.35	7.50	7.84	8.17	8.51	8.86	9.20	9.55	9.90	10.20	10.55	10.90	11.25	11.60	11.91	12.26	12.58	12.90	13.28	13.60

STEAM CONSUMPTION OF AIR COMPRESSORS.

TWO-STAGE COMPRESSION.



STEAM CONSUMPTION OF AIR COMPRESSORS.

follows: A steam consumption per indicated horsepower hour is assumed based upon an understanding of the type of steam end of the compressor, the steam pressure, cut off, vacuum if condensing, etc. Under this assumed figure on the line opposite the required air pressure, will be found the pounds of steam consumed per 100 cubic feet of free air compressed. The accuracy of these tables in practice depends upon the correct assumption of the indicated horsepower steam consumption. Where this cannot be exactly determined the tables can at best be considered as only an approximation.

The tables will, however, be found very useful for quickly making comparisons as to the amount of fuel consumed by the various types of air compressers, thus showing approximately the expected yearly saving by the use of, for instance, a compound as compared with a simple machine. For example, a straight line compressor with a steam consumption of 30 pounds, single-stage compression to 100 pounds gage, requires 9.9 pounds of steam per 100 cubic feet of free air compressed. A compressor with duplex steam cylinders, at the same steam consumption, but with compound or two-stage air cylinders, requires 8.42 pounds of steam. A compressor with compound steam cylinders, non-condensing, with a 26 pound steam rating and compound air cylinders requires 7.3 pounds of steam, while a high-class Corliss compressor using steam at high pressure with compound steam cylinders running condensing with a water rate of 17 pounds (including the condenser) and with compound air cylinders, requires 4.77 pounds of steam, or one-half as much as in the first example.

The average man, however, thinks in pounds of coal rather than in pounds of steam. For the purpose of comparison it will usually be better, therefore, to reduce deductions to terms of pounds of coal burned per hour or per day by dividing the steam consumption by 7, since a fair evaporation for average conditions is 7 pounds of water per pound of coal burned. This states the case upon a dollars and cents basis when the price of coal is known.

H. V. Conrad.

[The diagram, page 4671, embodies everything contained in the tables and requires practically no explanation. The steam consumption for single stage compression is represented by the oblique lines which rise from the lower left hand side, and the lines for two-stage compression start from the lower right hand side. The numbering at the bottom of the table is therefore reversed for convenience of reading from either end. For general purposes the diagram may be found more convenient than and practically as reliable as the tables.—Ed. C. A.]

THE "WESTFALIA" RESCUE APPARATUS

A modified form of the well-known "Shamrock" type of rescue apparatus has been introduced by the *Armaturen und Maschinenfabrik* Westfalia, of Gelsenkirchen. As shown by the diagram, the two steel oxygen cylinders, each charged with 120 litres (4.23 cubic feet) of oxygen, are carried in an inverted position on the shoulders, an arrangement enabling the pressure gage, reducing valve, safety valve and injector to be placed near the store of oxygen in such a manner that the injector, assisted by the oxygen issuing from the jet, forces the aspirated circulating air, and any accompanying water, from above downward. The air and oxygen are conveyed through the flexible pipe A into the inhaling pipe and attached mouth pipe B, the nozzle of which is divided into two chambers by a horizontal partition, so that the exhaled air is conveyed through the lower chamber and pipe C leading to the regenerator.

This latter consists of a slightly arched metal case, shaped so as to fit across the chest of the wearer, and fitted with ten superimposed sheets of wire gauze. A sheet of strong absorbent paper is inserted halfway up, and both the top and bottom halves are filled with granulated caustic soda and potash. The re-purified air is led through the pipe D to the back of the wearer, and, being cooled there by passing through a metal pipe, bent like a frame around the oxygen flasks, is aspirated by the injector, and being enriched with oxygen, resumes its circulating course. Both air tubes communicate with the corresponding halves of a bag behind the regenerator—an arrangement affording a reservoir of air for emergencies and facilitating respiration. The shut-off valve for the two cylinders is accessible to the wearer; and the lower extremity of the exhaled air pipe is fitted with a detachable cap for catching saliva (which is often secreted copiously, especially by unskilled wearers), and a blow-off valve for relieving excessive pressure of air or oxygen. A whistle may also be provided in the pipe leading to the reducing valve, and arranged to blow as soon as the internal pressure falls to 30 atmospheres, thus indicating to the wearer that the supply will only last about another half-hour, and that it is therefore time to retire. When the pressure falls below 25 atmospheres the whistle is closed by the action of a spring. The total weight of the apparatus, ready for use, including leather knapsack for covering the oxygen bottles, is 39 to 40 pounds.

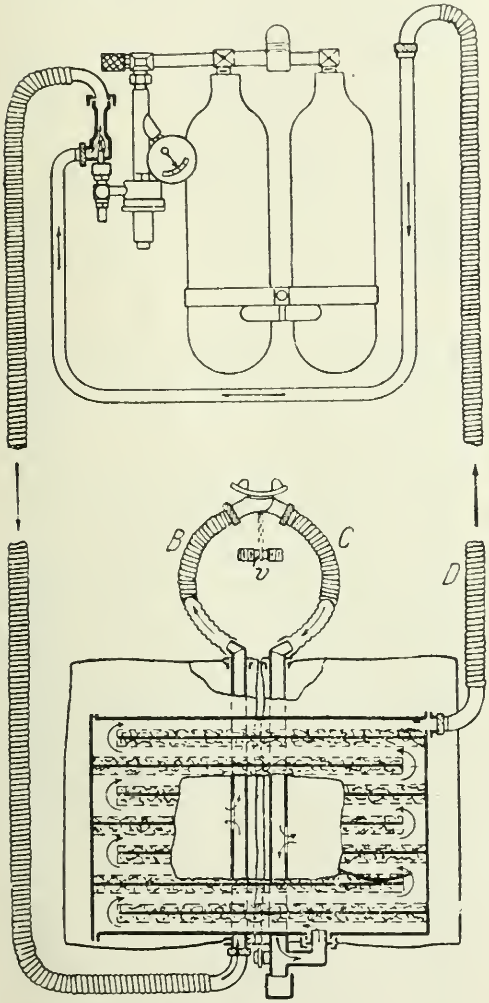


DIAGRAM OF RESCUE APPARATUS.

From trials made for periods of two hours each, the wearers being engaged in work, it appears that the absorption of carbonic acid is quite sufficient in view of the high percentage of oxygen in the air of the apparatus, and the wearers experienced no particular inconvenience in performing their tasks. The percentage of CO_2 in the inhaled air ranged between 0.22 and 1.66 per cent in all the trials except one (when it was 2.4 per cent) at the end of two hours. The volume of air circulating in the apparatus was 55 to 79 litres (2 to 2¾ cubic feet) per minute, the pressure of the injector being equal to 8 to 11 centimetres (3¼ to 4¼ inches) water gage.

THE GAGE FROZEN UP.

PIPING AN AIR GAGE

Jim Peters learned his trade at Clark Bros.' engine works, and continued to work there after his apprenticeship was served. He was considered a good man, capable of doing almost any job, steady, sober and industrious, but he had one fault that sometimes led him into blunders; he did not always find out the "reason why." He had learned almost everything he knew about the trade by experience, and had accepted many shop practices without fully knowing why they were followed. One of his blunders—the last—was piping an air gage, and what he learned from that experience was valuable, for after that day he made it a rule never to do anything without knowing *why* he did it.

Ben Clark, the junior member of the firm, was the superintendent and general foreman of the machine shop. When an air compressor plant was put in to operate pneumatic hammers and riveters in the boiler shop, the "super" put Jim on the job, which included the erection of the air compressor in the engine room, lines of piping to the shops, and a big receiver in the boiler shop. An air gage on the receiver was called for by the specifications, and Jim duly put it up in the way that he had learned was the correct thing for steam boilers, that is, with a siphon-shaped pipe connection.

The job was completed late in November, and all went well for several weeks, until one frosty morning in December the foreman of the boiler shop called the super's attention to the fact that the air gage on the drum showed not a pound pressure although the pneumatic hammers were making a merry din. One glance at the pipe connection told the super what was the matter. Going into the machine shop he walked up to Jim and said:

"Did you ever stop to think?"

"W-w-what's the matter now?" said Jim, growing red in the face, for he "smelled a rat," as the boys say.

"Why do you connect a *steam* gage with a siphon pipe?"

"I-I-I don't know," confessed Jim.

"Just what I thought," said the super, "for if you did you wouldn't have been such a fool as to put one on an air gage, especially in a cold boiler shop. Have you worked all these years here without learning that the siphon loop is simply a trap for condensation to protect the works from the hot steam? Pretty thing, though, to put on an air drum to freeze up over night. Looks nice, but you'd better straighten it."

Jim is nearly through with his correspondence course now, and he is growing to think that perhaps the air gage job was a good thing after all.—*Machinery.*

LIQUID AIR AN EXPLOSIVE IN COAL MINING

Some account of the practical use of liquid air in coal mining is given in a recent issue of *Montan Zeitung*. It was first used in combination with other materials, but is now used alone, its explosive power depending upon its property of turning suddenly into vapor at an elevated temperature. If the vessel in which the liquid air is contained is sufficiently tight, very high expansive powers are attained. For this reason it is stored in vessels having a small opening. This property of the liquid air makes it necessary to place the cartridge in place in the rock before it is loaded. In English mines the cartridges are made of thick phosphor bronze, the loading being calculated so that the pressure reaches 5.6 kilograms per square centimeter (80 pounds per square inch). The explosion takes place in six or eight minutes after loading and about 30 tons of coal are broken by one shot. The coal falls in blocks about 60 centimeters (2 feet) in circumference. A heavier loading of the cartridge causes the coal to be broken into powder.

A UNIQUE CHIMNEY FAILURE

Mr. Worcester R. Warner, of the Warner & Swasey Company, Cleveland, recently addressed a letter to the smoke inspector of that city, in which he said:

"I write to ask your suggestion in regard to a chimney which we built two years ago, which we have been using for the past year. I believe the general impression is that chimneys are used for the purpose of carrying away smoke, but this new one that we have been using for the past year does not seem to fill the bill in any sense, for it not only does not carry away smoke, but the bricks at the top even are nearly as clean and free from grime as when it was erected. Should you happen to be out in this neighborhood I would be glad to have you call and give us any suggestions which your experience may lead you to offer looking toward the proper utilization of this chimney. The furnace under it is developing at least 350 horse-power, and the coal we are using is the cheapest kind of slack. We have, however, thus far been unable to make any smoke. Can you tell us what is the matter?"

The cause of the failure of this chimney to emit the customary smoke is in the fact that the grate surface and the firebox space are much larger than usual, and that there is no crowding of the fire. The same conditions would result in similar failures in other cases, and the chimneys, useless as smoke conveyors, might be looked up to as monuments to perpetuate the fame of good engineering.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Established 1896.

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For the convenience and satisfaction of all concerned, it has been determined to close Volume XII with the present issue, and hereafter the volume will begin and end with the year. We are glad to be able to say that Compressed Air is prospering and growing, and with the coöperation of subscribers and advertisers we may hope to do much more for each other than ever before.

THE SHINING OF THE SUN

The sun shines everlastingly upon the United States and gives us constant and rapid growth. Our 85 millions of people increase by 2 millions a year and our wealth grows still faster. In 1890 the total value of our farm products was $2,466,000,000, in 1900 it was $4,717,000,000, while this year the aggregate is $7,000,000,000, and the value of our manufactured and mining products is two and a half times this, or $18,000,000,000. These are ready money values. The money should normally be spent over and over again, much of the spending following almost immediately, since other crops and other annual masses of products will be crowding upon us. Both the handling of the material products and of the monies which represent them bring special embarrassments by their very magnitude. Our transportation facilities do not grow fast enough nor our stocks of handy money either. We are tumbling over ourselves and we can't get out of our own way and as we stumble our headway is checked.

Another aggravation seems to have little connection with the above as to cause, but cooperates beautifully with the rest for the promotion of disaster. Worst of all for us seems to be the fact that the sun shines not only, as we are assured, upon the unjust as well as upon the just, but also upon the pessimist, and it would seem that the more generous is the sun with his rays of beneficence the more rankly does the pessimist grow. When things are at their best the pessimist is at his worst. When things are about as bad as they can be his occupation is gone. When we are flat on our backs there is no way to look but upward. The sick man may soon be continually assuring his friends that he is certainly better than he was before he began to improve.

It is easy enough to blame Wall Street and the inelasticity of our currency. Wall Street could not have its opportunity to keep on selling things down and down except for those who can be discouraged or scared into letting their holdings go. Our currency should have more elasticity, we are told, but when morbid impulse gets full swing and runs on the banks begin and every pessimist grabs and locks up every dollar he can reach, the elasticity must be phenomenal not to reach the point of rupture.

There is no time and no place where the pessimist cannot do more harm than good. "I told you so," when calamity comes, is only a masquerade of wisdom. He who "Never dispaired of the Republic" was the ideal statesman, and he who is sure that the sun never ceases to shine upon us is the stable and winning man of business.

THE PROBLEM OF THE AIR COMPRESSOR

Correct practice in industrial lines is of slow development. Never are the best means or the best methods first thought of or adopted, and the later ways of doing things generally show improvement and advantage over all which have preceded them.

There is the lubrication of machinery, for instance. We may suppose that it was known almost from the first that oil is good to stop the squeaking of a wheelbarrow, and it soon came to be understood, no doubt, that oil will also make things run easier, and so the hand oil can came into existence to be used when thought necessary, and often under compulsion to relieve ears or muscles. To-day the need of lubrication is recognized as constant, and continually running plants are provided with a continuous circulation of the lubricant.

The air compressor—speaking here chiefly of the steam-driven machine—is a curious and pertinent illustration of this habit of first adopting the crude and the inefficient, and of the later gradual adaptation of the machine to its complicated and exacting duties. The rock drill came into existence, and it at once demanded a supply of compressed air for driving tunnels, sinking shafts and for general mining work. Its demands were so urgent that practically anything which would go and keep going, maintaining the required air supply, was at first accepted. Not only were the earlier styles of machines crude and wasteful, but they were surprisingly long retained, and only quite recently has the demand for economy and complete adaptability in air compressors, as in other machinery, decidedly asserted itself.

The steam-driven air compressor has to satisfy many more conditions than at first glance may appear, and the designing of such a machine is a much more complicated task than that of any steam engine or any water pump. The range of opportunities, either of waste or of saving, is decidedly greater in the air compressor than in the steam pump or the stationary steam engine. Even in the steam end of the machine—looking at that alone—the requirements are quite different, for while the stationary engine must maintain a constant speed under a variable load, the compressor has a practically constant load per stroke, while the total amount of work required in any given time may vary widely, thus necessitating, as the most obvious solution, a continually varying speed.

When the steam and the air cylinders are in a straight line, the pressure in the one being directly applied to the overcoming of the resistance in the other, we have in every stroke the continually diminishing pressure in the steam cylinder opposed to the continuously increasing resistance in the air cylinder, so that while the total pressure in the steam cylinder may be quite sufficient for the work required of it, the distribution of it is unfortunate, and somewhere in the machine must be provided a means of storing the surplus of force at the beginning to be given out again at the end of the stroke. In duplex machines the two sides help each other over these hard places, so that if the fly-wheel is depended upon to be the equalizer and distributor, a lighter wheel is required for the two sides of the machine than would be required for either side alone.—*Cassier's Magazine.*

CORRESPONDENCE

COMPRESSED AIR IN THE UNIVERSITY OF MICHIGAN

Editor Compressed Air:

I noticed an article some time ago in your magazine stating that the subject of Compressed Air had been taught as a distinct subject in but one university in this country, and I wish to correct the mis-statement. Compressed Air has been taught at this university as a separate subject for ten years. At first it treated Compressed Air and Refrigeration in one class, but these have now been separated and we devote two hours per week for half a year to recitations on Compressed Air. The class starts with low-pressure types of compressors, then high-pressure compressors are taken up and two or three stage compression, and in the class we also teach on the theory of centrifugal fans and pressure blowers.

John R. Allen,
Junior Professor of Mechanical Engineering.

"DIFFERENT VACUUMS"

Editor Compressed Air:

Allow me to protest against the definition of "vacuum" of Tecumseh Swift in your November issue. He says the "actual vacuums we know about are only partial differences and deficiencies as compared with fullness or excess of pressure elsewhere." The last six words are the ones to which I object.

They should be changed to the words "atmospheric pressure." If the examples of exhausting from high pressure into external atmosphere, or from rock drills at high pressure into a pressure of 25 pounds gauge in a tunnel, can be considered exhausting into a vacuum, then the exhaust of the high-pressure cylinder of a triple expansion engine into the first intermediate receiver might also be called exhausting into a vacuum. The fact is that the word "vacuum" is never used by good engineering writers in the sense in which Mr. Swift uses it in this article. We have enough troubles with the English language now, without having it further corrupted by expanding the meanings of words in common use to such an extent as Mr. Swift would expand them.

Wm. Kent,
Dean and Professor of Mechanical Engineering, Syracuse University.

PNEUMATIC MICROMETRICS

Editor Compressed Air:

We all of us have some respect for the atmosphere, and we generally understand in a way that we couldn't get along very well without it! yet many of us have an idea that it does its work in a rough kind of way, notwithstanding that it gets there every time. The fact is that the atmosphere is one of the instruments by whose aid nature does some of its finest work, and that relatively to Earth as a whole its functions are adjusted with micrometric precision.

I suppose that my favorite plaything—in my mind—is an eight-inch terrestrial globe, and I am particular about the size of it, as that enables me to do my thinking to scale, a very necessary condition if my thinking is to be of any account. Earth is understood to be about eight thousand miles in diameter, and on our eight-inch globe, therefore, a thousandth of an inch will represent a mile. This at once makes things on Earth's surface look very small, and the heighths and the depths which make our scenery for globe trotters to laud and magnify become too minute to detect.

If there was a fellow big enough to hold Earth in his hand like an orange its surface would appear to him smoother and more highly polished than glass. If we suppose our eight-inch globe to be as highly polished as possible all over its surface and if we paste upon it a bit of paper a thousandth of an inch thick, the thinnest tissue paper we can get, that will of course be a mile high, and it will represent the range of altitudes within which 95 per cent. or more of the human race live and move and have their being. Dwellers on plains and prairies who know nothing higher than a two-story or a three-story house may be assumed to keep all their goings up and goings down within a vertical range of fifty feet, one-hundredth of the thickness of our bit of tissue paper, one one-hundred-thousandth of an inch (.00001). I as a New Yorker have a vaster range of altitude. I do my coming and going on Broadway. I am doing this writing 150 feet above the sidewalk and I take my lunch in a restaurant 300 feet above the sidewalk, so that in my daily life I can boast of a vertical range of at least .00006 inch on my eight-inch globe.

In this connection atmospheric air, "free air," may do some micrometer work for us. I have a pocket aneroid barometer, which, as everybody knows, is simply an air pressure gauge, that is another of my habitual playthings—this also mostly in my mind—and I have tried it in the elevators of some tall buildings. I find that this handy instrument will show a difference in the pressure of the air with a change of elevation of 25 feet, corresponding to .005 of the thickness of the sheet of tissue paper or to .000005 inch on the diameter of our eight-inch globe. There are fine instruments in use by engineers which will show a difference of elevation of 5 feet, which would be .001 of the thickness of our bit of tissue paper, or .000001 inch, which would be .000000125 of the diameter. The difference of air pressure per square inch for a difference of 5 feet in altitude would be about .0025 lbs. This makes it look after all as if the air did some pretty fine work.

While the actual pressure of the air in any given locality fluctuates constantly, so that a barometer is practically never at rest, the mean pressure is maintained with wonderful constancy. This pressure depends ultimately upon the total quantity of air in existence, which by its weight presses upon the lower stratum with which only we are in touch. Notwithstanding that both animal and vegetable life are constantly absorbing the constituents of the air, these are constantly removed or replaced, so that both the total volume and the weight of the air are maintained and the proportions of its constituents show no change.

A bit of the page of an ordinary book, say .005 inch thick, would represent on our little globe the highest land of Earth, and a much greater range of altitudes than it is ever possible for man to occupy, while the thickness of tissue paper first assumed represents the very greatest depths beneath the surface of Earth of which we have any knowledge by actual contact or observation. The air is our jailor and must ever keep us from breaking our bounds either upward or downward. When we keep our normal level our jailor is our best friend and benefactor, but we cannot escape our aerial environment in any direction.

TECUMSEH SWIFT.

QUESTIONS AND ANSWERS

T. F. H., Cumberland, B. C.—*Q.:* How is the horse-power of an air compressor computed? For instance, we have an air compressor, two-stage, with low-pressure cylinder, 32" diameter; high-pressure, 20"; stroke, 30". This machine is catalogued at 347 and 390 horse-power at 80 and 100 pounds air pressure, respectively. I would like to know how this is worked out.

A.: In the above enumeration one absolutely essential particular is omitted: the number of revolutions or double strokes per minute. The actual horse-power of a running compressor can only be computed from a full set of indicator cards. In the present case we made a rough computation of the power required in single-stage compressors, or as if all the work of compression was done in the first or low-pressure cylinder. From Table II., page 29, of Richards' Compressed Air we find that the mean effective pressure for compressing to 80 lbs. is 36.6 lbs. Assuming the speed to have been 80 revolutions, or 400 feet, per minute, we then have the following statement: $32^2 \times 7854 \times 36.6 \times 400 \div 33000 = 356.79$. This is the theoretical horse-power required, and if we add 10 per cent. it will be near the actual. Then $356.79 + 35.68 = 392.47$. If we deduct from this 12 per cent. for the probable saving of power by two-stage compression, we have: $392.47 - 47.09 = 345.38$, which is very near the figures given above by our correspondent. For compressing to 100 lbs., single-stage, the mean effective pressure is 41.6 lbs. Then we have as before: $32^2 \times 7854 \times 41.6 \times 400 \div 33000 = 405.50$, which with 10 per cent. added gives us $405.50 + 40.55 = 446.05$, and deducting 12 per cent. as before we have $446.05 - 53.52 = 392.57$, which also is near the figures of our correspondent. The deduction for saving by two-stage compression should of course be greater for compression to 100 lbs. than to 80 lbs. It is to be remembered that the saving of power in two-stage compression is by no means the only, and often not even the chief consideration to recommend two-stage compression. The avoidance of the high and often dangerous temperatures is not only important, but also imperative if the compressor is to run with safety and at sufficient speed to be efficient.

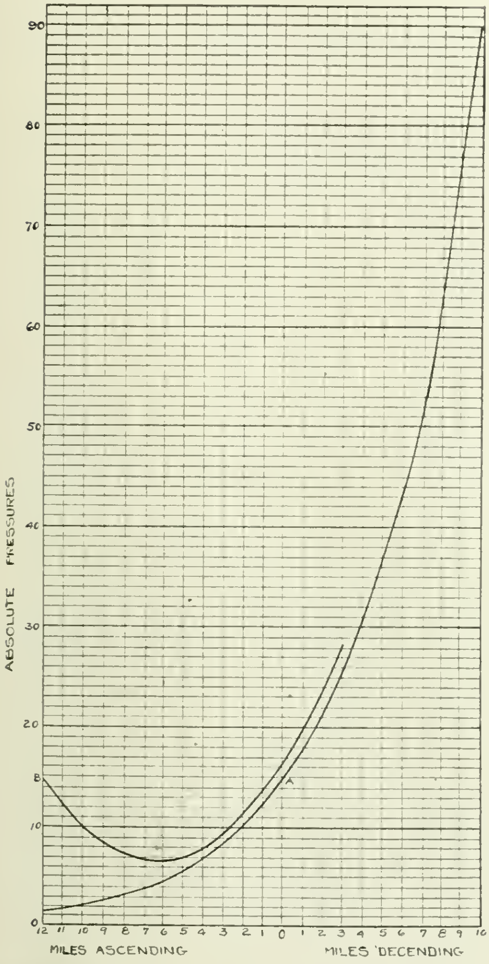
C. T. B., St. Louis.—*Q.:* The letter of Mr. Tecumseh Swift in your October issue, in which he suggested that the air pressure at a depth of a dozen miles below the surface of the earth would be over 100 lbs. rather surprised me and I tried to do a little figuring about it. I dug up an empirical formula for computing air pressure at different altitudes which was published in COMPRESSED AIR several years ago. The following is the formula:

$$A = 14.72 - \frac{57{,}000\,N - N^2}{100{,}000{,}000}$$

A is the absolute pressure at any elevation and N is the elevation in feet.

The writer said: "This formula gives results in some cases varying about one-sixth of one per cent. from certain published tables, but it has the advantage that when plotted it gives a *perfect* curve, which no table that I have seen will do."

Thus assured, I started my figuring with perfect confidence, beginning first with altitudes above sea level, and the following are the results as far as I went:



Absolute Air Pressures at Different Altitudes by a Freak Formula.

Sea level	14.72	40,000	7.92
5,000 feet	12.12	45,000	9.32
10,000 “	10.02	50,000	11.22
15,000 “	8.42	55,000	13.62
20,000 “	7.32	60,000	16.52
25,000 “	6.72	65,000	19.92
30,000 “	6.62	70,000	24.72
35,000 “	7.02	75,000	28.22

Here the pressure, instead of constantly decreasing, actually began to increase above 30,000 feet altitude, but, as the writer said, a perfectly smooth curve resulted, as I have plotted on the scrap of section paper herewith (see line commencing at B on the diagram). With such luck in figuring up hill I did not try going below sea level, as the result would of course be similar, only reversed. Can you suggest a more satisfactory formula?

A.: We suggest another empirical formula or rule: Deduct successively 17 per cent. from the absolute pressure for each mile of ascent, or add 20 per cent. for each mile of descent. The following results will be obtained:

ABSOLUTE AIR PRESSURES.

Ascending.		*Descending.*	
Sea level	14.7	Sea level	14.7
1 mile	12.2	1 mile	17.64
2 “	10.13	2 “	21.17
3 “	8.41	3 “	25.43
4 “	6.98	4 “	30.43
5 “	5.8	5 “	36.45
6 “	4.98	6 “	43.66
7 “	4.14	7 “	52.33
8 “	3.44	8 “	62.77
9 “	2.86	9 “	75.26
10 “	2.38	10 “	90.26
11 “	1.98	11 “	108.34
12 “	1.65	12 “	129.95

The diagram shows that these figures also make a perfect curve. The sea level start of the curve is at A, reading down to the left for the diminishing pressures in ascending and upward to the right for the increasing pressure is descending. The shorter curve shows the results from the formula referred to by our correspondent. The sea level start for this curve is at B.

L. I., York, Eng.—*Q.:* I want an engine driven by compressed air to run about ten minutes at a time and to develop ¼ horsepower at 1,500 revolutions per minute. What would be dimensions of engine, capacity of receiver and what charging pump or compressor would be required?

A.: The question permits the adoption of a variety of pressures and other particulars in the solution of it. We assume here a working pressure of 50 lbs. at the motor with a cut off at one half stroke, which would give a mean effective pressure per stroke (see Richards' "Compressed Air") of 37 lbs., say 35 lbs. Then with an engine cylinder 1.25 in. diameter and 1.25 in. stroke at 1,500 revolutions per min. the horse-power developed would be:

$1.25^2 \times .7854 \times 35 \times 312.5 \div 33000 = .4068$ h. p.

The factor 312.5 is, of course, the piston speed in feet per min., which we are well aware is excessive for so small an engine. The .4 horse-power obtained, when allowance is made for friction and other losses, would not be greatly in excess of the .25 horse-power required. The air consumption per min. would be:

$1.25^2 \times .7854 \times 1.25 \times 1500 \div 1728 = 1.33$ cu. ft.

This would be 13.3 cu. ft. for 10 minutes, and if we add 50 per cent. to this for clearance, leakage, etc., which is not too much to cover all contingencies, we would require just 20 cu. ft. of air at 50 lbs., or:

$15 : 50 + 15 :: 20 : 86.66$ cu. ft. free air.

The initial receiver pressure would of course be required to be much higher than 50 lbs., the air being delivered through a pressure reducer and maintaining a constant pressure of 50 lbs. at the motor until the pressure in the receiver was down, or nearly down, to that, when it would require to be recharged. The contents of the receiver below 50 lbs. would of course not be usable and must always remain in the receiver. Say that a pressure of 210 lbs., or 15 atmospheres, was obtained in the receiver to start with, then a receiver 1.5 feet dia. and 5 feet long would be sufficient for the purpose. These being the internal dimensions, the cubic content would be:

$1.5^2 \times .7854 \times 5 = 8.8$ cu. ft.

This being filled with air at 15 atmospheres the free air represented would be $8.8 \times 15 = 132$ cu. ft. When the 86.66 cu. ft., say 90, required to run the motor 10 minutes had been discharged there would remain in the receiver $132 - 90 = 42$ cu. ft. and the pressure of this would be: $8.8 : 42 :: 15 : 71.5$, and $71.5 - 15 = 56.5$ lbs., only a little in excess of the requirements.

The capacity of the compressor for charging the receiver would depend upon the time allowed for the compression, and it is not necessary to go into any computation concerning it. In any case the power required for the compression would be considerably greater than that realized at the motor. The work of compression would increase as the pressure rose in the receiver. The free air consumption at the motor being 8.66 cu. ft. per min., the theoretical power required to compress this volume to 50 lbs. (see Richards' "Compressed Air") would be $8.66 \times .1195 = 1.03$ h. p., to which should be added at least 15 per cent. to cover all losses. This would be the power required at the beginning of the recharging of the receiver, while when the 210 lbs. terminal pressure was approached the power required would be more than double this. As a scheme of power utilization this use of air is not to be recommended. The mode of computation here adopted might have been greatly complicated by considering the temperatures of the air at the different stages, but time and space would not permit.

COMPRESSED AIR AND GRAMOPHONES IN INDIA

A lady whose friendship for Compressed Air began when she was "typist," as she modestly puts it, to a live machinery man at Kalgoorlie, Australia, but who now resides at Singapore, India, kindly sends us the following clipping from a daily of that city:

The local agents of Pathe Freres gave a trial run yesterday afternoon to the latest device in gramophones, namely one worked by compressed air. The trial, which was attended by several people interested, proved quite successful. The new system is worked by electricity. Current is turned into a small compressing machine which transmits the compressed air into the machinery of the gramophone where it establishes a far better pressure on the sapphire point than can be obtained under ordinary circumstances. The records come out much clearer and louder and there is greater steadiness. The machine will soon be on the market and is so arranged that it can be adapted to any house electric connection and will later be supplied with manual pressure. The gramophone with this machine and Pathe records, etc., is really a quite efficient substitute for a band and the music is the nearest approach to the actual music we remember to have heard. While the gramophone was in operation a series of excellent cinematograph films were run off and showed the great range of subjects this company possesses.

NEW BOOKS

The Use of the National Forests.—U. S. Department of Agriculture, Forest Service, 42 pages 5x7 inches, 7 full-page half-tones. There are, we are told in this book, 173 national forests in different States and Territories, with a total area of 148,000,000 acres, and this interesting little book tells of the purposes for which these forests are reserved, the wise and enlightened methods by which they are cultivated and cared for and the beneficial results for the nation and the individual.

The Blacksmith's Guide, by J. F. Sallows.—The Technical Press, Brattleboro, Vt., 157 pages, 4½x7¼ inches, 150 or more illustrations. This neat little book is the work of a practical, successful every-day working blacksmith. It describes the various operations of the trade and the tools used, but it is specially devoted to the responsible work of tool making in all its details, with copious information concerning the heat treatment of steels, annealing, hardening and tempering. Three of the illustrations are in color, showing heat and temper scales and the artistic effects of case-hardening.

Suplee's Mechanical Engineers' Reference Book is attaining the success it so well deserves. It has been thoroughly revised, and appears in a third edition with 62 pages of new matter. It contains more useful and immediately available engineering data than any other book in English. Its 400 illustrations are as useful in their way as the text.

Economy in Lubrication. By William A. Mayes, Reading, Pa., 28 pages, 5⅜x7¾ inches. Illustrated with half-tones, diagrams and charts. The purpose seems to be to argue, in whose interest does not appear, that grease is bad and oil is good for machinery. "Mailed for the asking."

TRADE PUBLICATIONS

Alundum, Norton Company, Worcester, Mass., 12 pages 3⅜x6¼ inches (nearly postal card size, but too long for enclosure in a common letter envelope).—Gives a very interesting and readable account of the production of Alundum in the electric furnace and of its various uses as an abrasive of the highest efficiency.

Simplex Concrete Pile Foundations, The Foundation Company, 115 Broadway, New York, 88 pages 6x9 inches.—This publication consists principally of excellent half-tones showing the actual employment of those concrete pile foundations under a great variety of conditions and for most responsible service.

Pneumatic Cranes and Hoists, Quincy, Manchester, Sargent Company, Chicago, New York, 36 pages 6x9 inches, numerous illustrations.—The hoists shown are of the familiar single cylinder direct lift type and various styles of cranes are shown in which they are applied. Valves, hose and various appurtenances are shown and lists of capacities, dimensions, etc., are given.

Catalogue of Steam Pumps, No. 35, A. S. Cameron Steam Pump Works, New York, 157 pages 6x9 inches, copiously illustrated. Tables and Useful Information.—These pumps normally have no exposed working parts and are built in a great variety of styles and sizes to suit all lines of service.

Handling and Storing Coal and Ore, Dodge Coal Storage Company, Philadelphia, 112 pages 6x9 inches, numerous half-tones.—The machinery under construction, installed and in use to date provides for the storage of 4,660,000 tons of coal. Many of the installations included are illustrated and briefly described in this publication. The devices employed are also treated in detail.

FREE ENGINEERING LIBRARY TO OPEN EVENINGS

The reference libraries of The American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and The American Institute of Mining Engineers, 29 West 39th street, New York, will be open evenings until nine o'clock on all week days except public holidays. These libraries, constituting practically one library of engineering, situated near the New York Library, in the new headquarters of the Engineering Societies, are available to members of the above societies, engineers, and the public generally, subject to proper regulations. Strangers are requested to bring letters of introduction from members or to secure cards from the secretaries of the respective societies.

The receivers assure the clients of The Westinghouse Machine Company and all others interested, that there should be no occasion for apprehension because of the company's application for a receivership. This action was deliberately and thoughtfully taken as a sensible and logical measure for conserving the interests of the customers, creditors and stockholders of a solvent institution which is doing a large and profitable trade. There has not been even a momentary pause in the operations of the company, and the personnel remains the same as heretofore.

NOTES

Mr. H. B. Ayers has become General Manager of H. K. Porter Company, locomotive builders, Pittsburgh. Mr. Ayers has been for the past two years in charge of the Canadian Locomotive Works at Montreal and before that he was General Manager of the Pittsburgh Locomotive Works, so that he is experientially qualified for the position.

The air expended in the coal controversy over the Pacific fleet would keep mining machines running long enough to dig fuel enough to keep the fleet at sea long enough to lick the Japs or any other bunch until they had cried "Enough."—*Coal Trade Bulletin.*

A new pneumatic mail tube is being laid in Philadelphia for connecting Station C, Nineteenth and Oxford streets, with Station J, Nineteenth and North streets. This is the beginning of a system, the contracts for which have been let, to connect the principal substations of the city with each other and with the central station.

The unit of coinage in Mexico is the peso and not the dollar, and to speak of Mexican dollars is incorrect. The value of the peso is only about one-half that of the United States dollar, this not referring to the relative weights of the silver coins. The sign of the peso is a capital letter P with two fine horizontal lines across the upper portion.

Fruit is being "naturally dried" in California by artificial means. A continuous draft of air at a temperature of 150 degrees is passed through trays containing the fruit with results highly satisfactory. Two weeks' time is saved in the drying of prunes and their condition is said to be better with less loss of weight.

It is stated by an English writer in *Nature* that the United States government spends annually more than $13,700,000 in scientific work, exclusive of the large grants for purely educational interests. The sum spent for similar purposes by the British government is about $1,200,000. The revenue of the United States is given as $762,375,000, and that of Great Britain $719,885,000, which indicates a surprising difference in the estimates of ultimate values in two nations with interests presumably so nearly identical and whose future is to be shaped by the same agencies.

Frank Gilroy, chief engineer of the New York Central's compressed air system in Buffalo, has invented a device for tamping up ties with pneumatic tools which assures a uniform stroke. Experts are of the opinion that such a method will solve the problem of broken rails. Mr. Gilroy's invention is to be tested on the West Shore at Utica.

The device for furnishing the air is carried on a skeleton rubble car and is said to be light enough for any ordinary gang to lift from the track. Rubber hose carries the compressed air to the tools, which are operated simultaneously on opposite sides of each tie and pound away at the rate of several hundred strokes each minute.

Statistics have again been obtained with reference to the use of coal-cutting machines in the United Kingdom. In 1906 there were 333 collieries where coal-cutting machines were at work, as against 295 in the preceding year. The total number of machines employed was 1,136 (as against 946 in 1905), of which 451 were worked by electricity and 685 by compressed air; the total quantity of coal obtained in 1906 by the aid of these machines was 10,202,506 tons. This is an increase of 2,100,309 tons compared with 1905, and 4,458,462 tons compared with 1904.

Nothing could be simpler than the working of a gas engine. "You see, when the piston comes up and compresses a lump of gas a spark jumps in and touches it off and the engine gives a poke, which turns the crank shaft around. Then the piston comes back and chases out the burned gas and takes in a fresh charge as it goes back; then it comes up and the load gets a spark and the piston is blown back and the crank shaft gets another poke, just as before. Every time a spark is let in the engine gets a poke, and gives it to the crank shaft, you see. It's perfectly simple and simply perfect."—*Life.*

Three-phase electric locomotives were started to run the trains through the Simplon tunnel. These engines took up almost the entire available section of the tunnel, acting much like a projectile and pushing large volumes of air before them, with great consumption of power and reduction of speed. Also in going from the cool outside air into the tunnel atmosphere, which is warm and moist, they become covered with a profuse condensation, so that some of the motors have given out because, it is supposed, of the moisture penetrating the insulation. Steam locomotives fitted with smoke consumers have therefore been adopted, at least for the present.

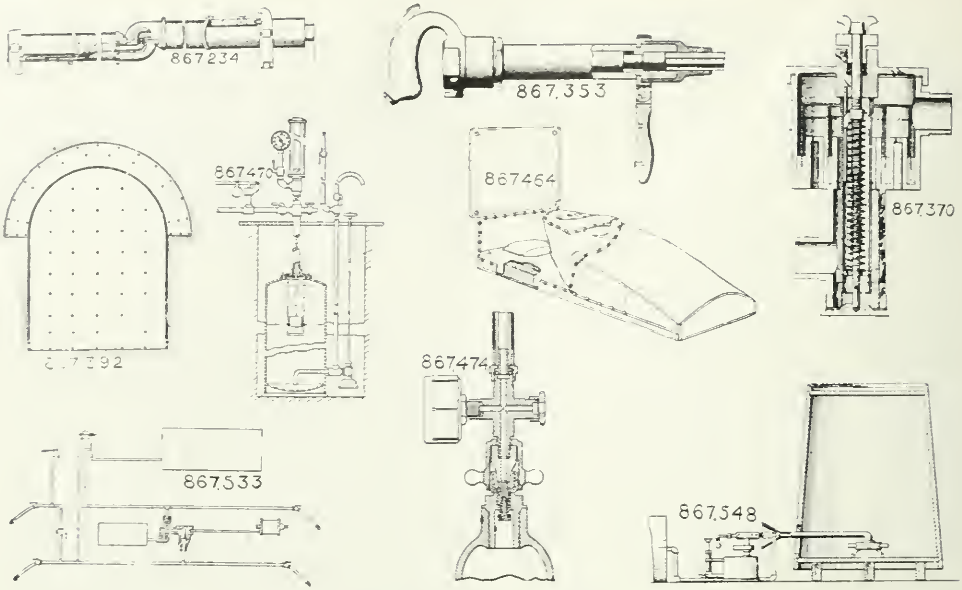
A pneumatic ammunition hoist for war vessels is under development by the U. S. Ordnance Bureau. It is believed that the new hoist will effectually prevent such accidents as the one which occurred last July on the "Georgia." Some of the members of the board which investigated that accident were of the opinion that friction on the rails carrying the ammunition car, in the type of hoist used, had ignited the charge; sparks have been observed when the rapidly moving car strikes the bend in the guide rails. The purpose of the new hoist is to prevent not only the falling of burning grains of powder, but also any such effects of friction; the carrier will travel in a heavy, seamless brass tube, preventing any possible access of sparks or burning grains to the powder delivered in the turret.

One of the largest blasts ever fired in France was discharged recently at the quartzite quarries at Cherbourg, and is said to have displaced 120,000 tons of stone. A tunnel measuring six feet wide and six feet high was driven into the face of the cliff for a distance of seventy feet, and at its end two branch tunnels, each twenty feet long, were driven to the right and left respectively. These branches ended in chambers forty feet apart and seventy feet from the face of the cliff, and measuring each ten by six by six feet. The chambers were charged with eight and a half tons of blasting powder and 280 pounds of dynamite, and the blast was fired electrically. The quartzite obtained from this quarry finds much favor in England as a road material.

The Federal Government of Switzerland has a monopoly of the alcohol supply industry of that country. Denatured or industrial alcohol is sold by the government at cost—about 25 cents per gallon. It is prohibited to mix any substance with denatured alcohol that would counteract the effect of the denaturization or change its taste or smell. There are two methods of denaturizing the alcohol—the complete and the incomplete. The complete method is applied to spirits which are to be used for heat, light and power purposes. This alcohol is fully denatured; pyridine is used as a base and the process is secret and frequently changed. Incomplete denaturization prevents the alcohol from being used as a beverage, but does not destroy its properties for special uses.

An explosive costing considerably less than dynamite, which was experimented with in the construction of the Simplon tunnel, is made by soaking meal or powdered charcoal in liquid air or liquid oxygen, the powdered carbon being first packed into a case made of stout paper and covered with an asbestos wad, through which passes a paper tube to the bottom of the cartridge. Just before firing, the liquid air is poured into the tube, and the firing is as usual by means of a fulminate cap. As the liquid air gradually evaporates, the period between filling and firing is limited to below ten minutes. A missfire is not dangerous, because at the end of half an hour the liquid has entirely disappeared and the cartridge may again be handled with safety. The use of this economical explosive had to be abandoned in the tunnel by reason of the quantities of carbon monoxide which it produced in the constricted space.

Rats are the cheapest mine scavengers there are; they are plentiful in the stopes of Bisbee and of the Comstock. The writer knows of no harm that they do underground, and, considering the great amount of good that they do, he would even advise their introduction in mines where the men eat underground. Rats are good indicators of impending caves in the stopes. When the rats leave a stope (unless it is due to some obvious cause such as the introduction into a stope of air-drills where formerly hand-drilling was used) it is time for the miners to leave also. The rats sometimes bother candles and, it is said by some, also dynamite, but this damage does not amount to much. In fact, the writer never knew of the rats bothering the candles or the dynamite at Bisbee, where the rats have plenty of chance to do so; probably they eat the candles only when very hungry. The Malthusian principle prevents an overabundance of rats at a mine.—*Mining and Scientific Press.*



PNEUMATIC PATENTS, OCTOBER 1.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

OCTOBER 1.

867,234. SAFETY-VALVE FOR AIR-BRAKE. Thomas Behan, Aliquippa, Pa.

867,353. PNEUMATIC HAMMER. Alfred J. Doughty, Detroit, Mich.

867,370. PRESSURE-EQUALIZING VALVE. Charles W. Henson, Chicago, Ill.

867,392. METHOD OF TUNNELING. David Maxwell, Detroit, Mich.

The herein described method of tunneling, which consists in preliminarily cutting or drilling to outline the cross-section of the tunnel, and also drilling exteriorly of such cross-section at the top of the tunnel, and subsequently dislodging and removing the material contained in the outlines area and in the exteriorly drille area; substantially as described.

867,464. PNEUMATIC SLEEPING-BAG. Thomas Abbott, Reading, Mass.

867,470. PNEUMATIC WATER-ELEVATOR. John E. Bourne and Orlando W. Stevens, Somerville, Ohio.

867,474. DEVICE FOR INFLATING TIRES, &c. Robert H. Campbell, Edmonton, England.

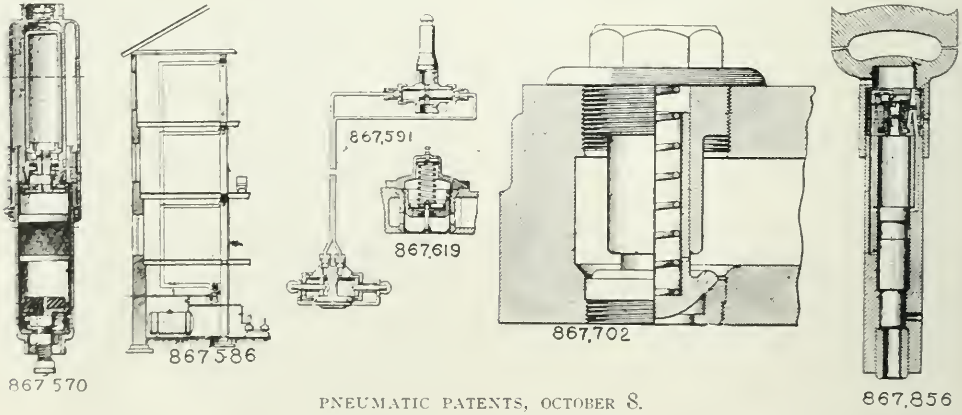
867,533. AIR-BRAKE SYSTEM. Henry N. Ransom, Cleveland, Ohio.

867,548. MEANS FOR DRYING THE INTERIOR OF VATS, &c. Jacob H. Beckman, Seattle, Wash.

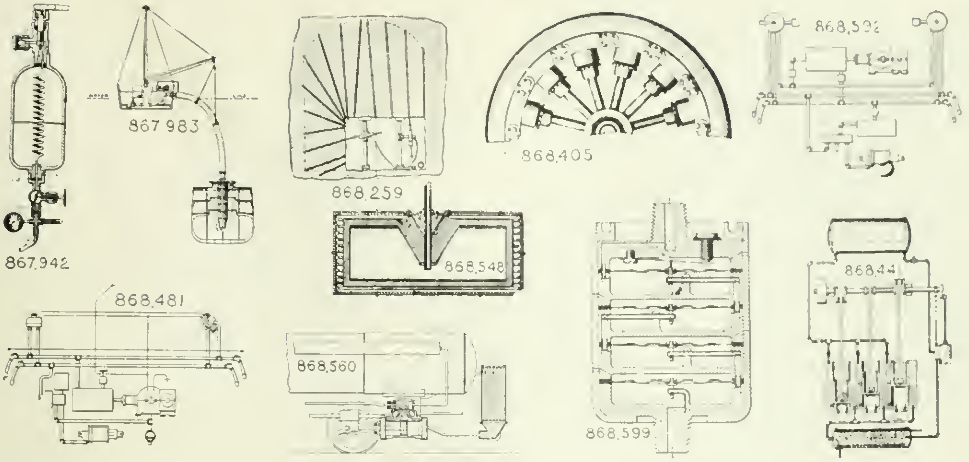
In a device for drying the interior of vats, means adapted to be arranged for movement within the vat for distributing air therein, a pipe leading from said means without the vat and having a funnel shaped mouth, means for heating the mouth of said pipe, and means for directing air under pressure into the mouth of said pipe, for the purpose specified.

OCTOBER 8.

867,570. PNEUMATIC SUSPENSION MEANS. James H. Clark, Richmond, Va.



PNEUMATIC PATENTS, OCTOBER 8.



PNEUMATIC PATENTS, OCTOBER 15.

867,586. LIQUID-DISTRIBUTING MEANS. Edward J. Moore, Cleveland, Ohio.

In liquid distributing means, a liquid storage tank having compressed air connections, and a line of distributing pipe for said tank having valved outlet connections, in combination with means to relieve said tank of compressed air, and an air intake valve for said line of pipe adapted to open automatically when the pressure is relieved within said tank, whereby the liquid within the pipe is drained back into said tank.

867,591. PNEUMATIC VALVE-CONTROLLING APPARATUS FOR GAS-BURNERS. Richard N. Oakman, Brooklyn, N. Y.

867,619. SELF-ACTING VALVE FOR COMPRESSORS AND THE LIKE. Ferdinand Strand, Schmargendorf, Germany.

867,702. DISCHARGE-VALVE FOR GAS-COMPRESSORS. Arthur F. Clarke, Butler, Pa.

867,856. PNEUMATIC TOOL. Edward M. Tobin, Barre, Vt.

OCTOBER 15.

867,942. COMPRESSED-FLUID CHARGING AND DISCHARGING DEVICE. Gabriel A. Bobrick, Los Angeles, Cal.

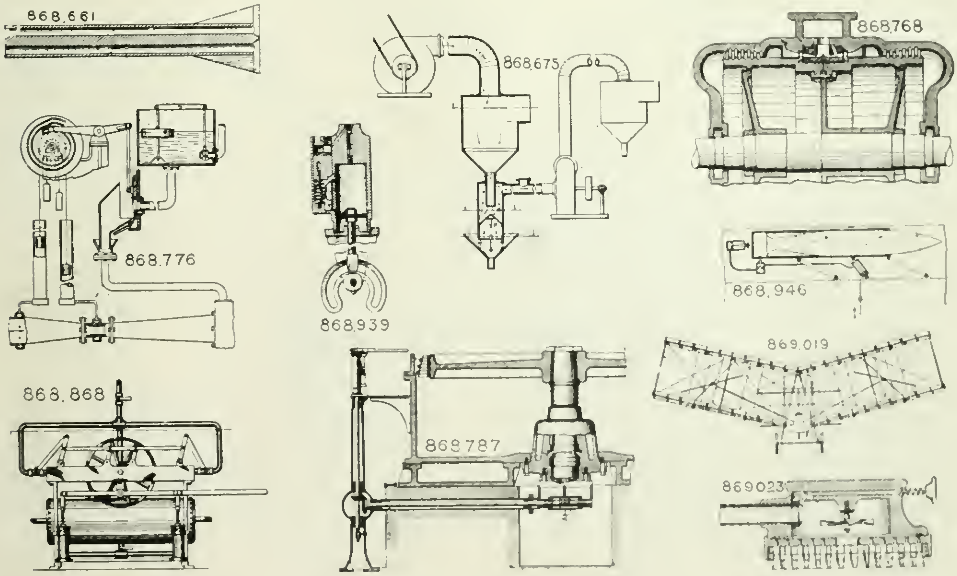
867,983. MEANS AND APPARATUS FOR RAISING SUNKEN VESSELS. Simon Lake, Bridgeport, Conn.

868,259. METHOD OF EXCAVATING ROCK TUNNELS. Patrick Ford, Chicago, Ill.

'The method of excavating rock tunnels comprising first constructing an under heading for the length of the tunnel and then arranging the air and the pipe lines close to the wall of the heading then throwing down the material from the roof of said tunnel into said heading and operating at either or both ends of the tunnel.

868,405. WHEEL. George F. Brandenburgh, Irvington, N. J.

In a wheel, the combination of a hub providing an annular chamber and means for supplying compressed air thereto, hollow spokes each inserted at one end



PNEUMATIC PATENTS, OCTOBER 22.

into the said hub in communication with the chamber thereof and being enlarged at its outer end, and hollow felly sections, one for each spoke and each provided with an arc-shaped chamber communicating with a tubular mouth having at its inner side a slideway for the enlarged end of its spoke.

868,441. COMPRESSED-AIR MOTOR. Charles D. Jenkins, Boston, Mass.

868,481. AIR-BRAKE SYSTEM. Henry N. Ransom, Albany, N. Y.

868,548. COMPRESSED-AIR TANK. William J. Griffin, Morley, Mich.

868,560. INTERHEATER FOR COMPOUND COMPRESSED-AIR ENGINES. Charles B. Hodges, Pittsburg, Pa.

In a compound compressed-air engine in combination with the high-pressure and low-pressure cylinders and their inlets and exhausts, of a receptacle for compressed air connected with the exhaust from the high-pressure cylinder and with the inlet to the low-pressure cylinder, and means for causing a current of air to flow over the surface of the said receptacle operative on the exhaust of air from the low-pressure cylinder, substantially as described.

868,592. AIR-BRAKE SYSTEM. Charles E. Barry, Schenectady, N. Y.

868,599. PRESSURE-REDUCING VALVE. Clyde J. Coleman, New York, N. Y.

OCTOBER 22.

868,661. PNEUMATIC AND OTHER DRILL. Martin Hardsocg, Ottumwa, Iowa.

868,675. SCREENING COLLECTOR AND SEPARATOR. Lee Lockwood, Des Moines, Iowa.

868,776. AUTOMATIC FLOW-REGULATOR FOR LIQUIDS AND GASES. John H. Gregory and Walter W. Jackson, Columbus, Ohio, and Frederick N. Connet, Providence, R. I.

868,768. ELASTIC-FLUID TURBINE. Raymond N. Ehrhart, Pittsburg, Pa.

868,787. ELASTIC-FLUID TURBINE. Oscar Junggren, Schenectady, N. Y.

868,868. AIR-MOTOR. Peter Kiefer, St. Louis, Mo.

868,939. PNEUMATIC PUMP. Hadley C. Reames, Los Angeles, Cal.

868,946. TORPEDO - PROJECTING APPARATUS FOR SUBMARINE AND SUBMERSIBLE VESSELS. Henri Smulders, Schiedam, near Rotterdam, Netherlands.

869,019. FLYING-MACHINE. John D. Pursell, Chattanooga, Tenn.

869,023. PNEUMATIC BRUSH. Jacob E. Schadle, St. Paul, Minn.

OCTOBER 29.

869,247. COMBINED MOTOR AND HAND OPERATED ROTARY BLOWER. Henry B. Keiper, Lancaster, Pa.

869,262. ASPIRATOR. Edwin Pynchon, Chicago, Illinois.

869,278. ROCK - DRILL - FEED MECHANISM. Thomas Turner, Ottumwa, Iowa.

869,288. SOUND-AMPLIFIER. Nathaniel Baldwin, Heber, Utah.

869,337. PNEUMATIC - DESPATCH - TUBE APPARATUS. Charles F. Stoddard, Boston, Mass.

869,373. VALVE MECHANISM FOR AIR-COMPRESSORS. Frank Lafferty, Elyria, Ohio, and Watson Spence, Philadelphia, Pa.

869,453. FLUID-PRESSURE MOTOR. Spencer Otis, Chicago, Ill.

869,542. PNEUMATIC CLEANING DEVICE. William J. Bergens, Pittsburg, Pa.

869,544. REGULATING DEVICE FOR DUST-REMOVING PNEUMATIC MACHINES. Jules R. Blum, Paris, France.

869,552. SIGNAL APPARATUS. Clarence W. Coleman, Westfield, N. J.

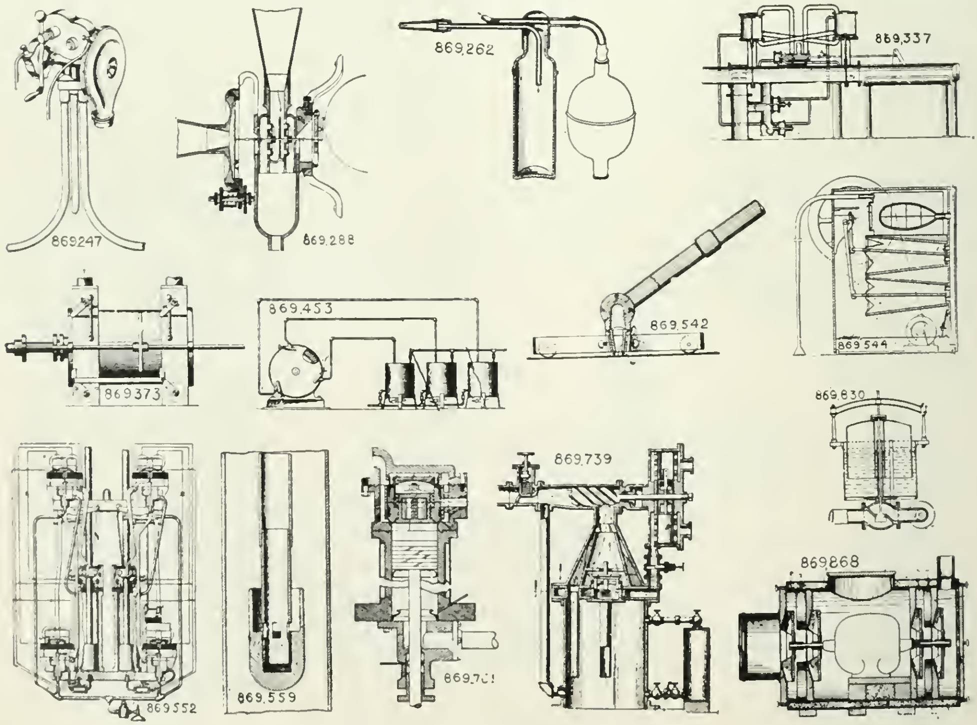
869,559. PUMP. Thomas Foy, Freehold, N. J.

869,739. AIR-COMPRESSING SYSTEM. Adelbert Sauer, Pittsburg, Pa.

869,781. PNEUMATIC PUMP. Daniel L. Holden, New York, N. Y.

869,830. GAS - PRESSURE - REGULATING DEVICE. Gustaf Dalen, Stockholm, Sweden.

869,868. ORGAN-BLOWING APPARATUS. Ira H. Spencer, Hartford, Conn.



PNEUMATIC PATENTS, OCTOBER 29.

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ENGINEERING

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